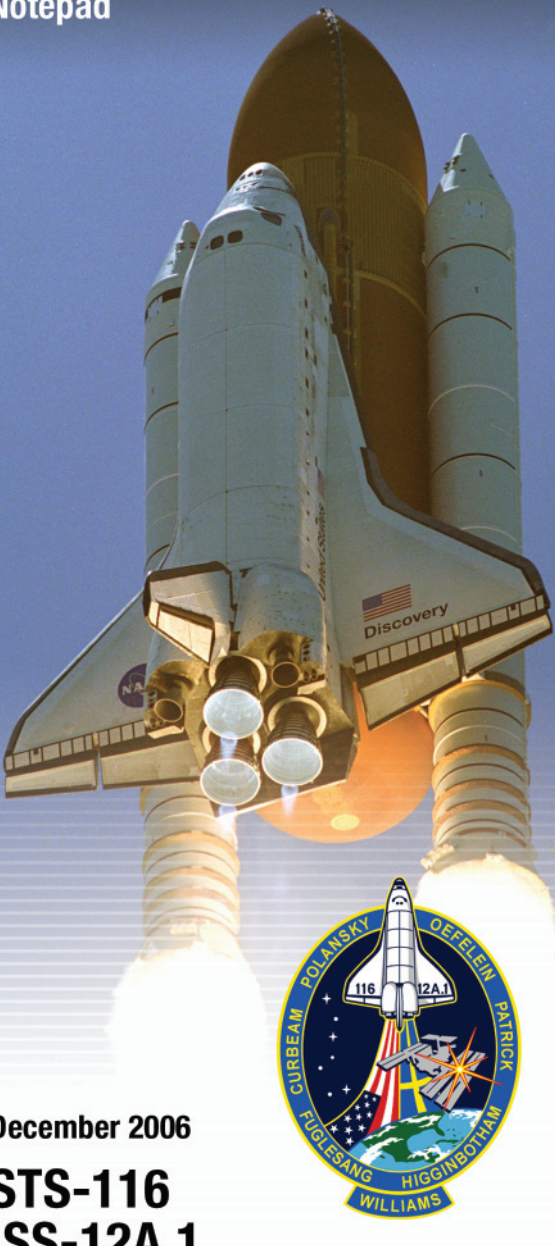
Reporter's Space Flight Notepad



December 2006

STS-116
ISS-12A.1

Boeing Communications

BOEING

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A COLOR GUIDE TO THE STS-116 REPORTER'S SPACE FLIGHT NOTEPAD

THE VISION FOR SPACE EXPLORATION

The vision to inspire begins with a dream of hope and knowledge, and ends with a mission of purpose and realization. In that manner, the nation's Vision for Space Exploration embodies humankind's instinctual desire to understand the fundamental questions about its existence and place in the cosmic universe.

Returning humans to the moon and then eventually sending them to Mars nurtures humankind's desire to push beyond the boundaries of the obvious and open the doors to a new frontier of possibilities.

Just as legendary American explorers Meriwether Lewis and William Clark, Robert Peary, Charles Beebe, and Neil Armstrong guided the world toward new experiences and possibilities on land, sea, and space, the emerging pioneers of the universe will motivate future generations to investigate, cultivate, and achieve.

During the past 10 years alone, astronomers have discovered the first solar system besides our own and more than 100 planets orbiting other stars. The nation's invigorated space exploration directive will bolster these accomplishments by increasing the use of robotic exploration to maximize our understanding of the solar system and pave the way for more far-reaching human missions.

Robotic explorers will visit new worlds first to obtain scientific data, assess risks to astronauts, identify space resources, send imagery back to Earth, and later provide assistance to human explorers on those worlds. Among these modern marvels are the highly successful and operational NASA Mars Exploration Rovers, Spirit and Opportunity. NASA's Lunar Reconnaissance Orbiter will gather data about possible moon landing sites and the polar regions and is scheduled for launch in fall 2008.

The space shuttle is the workhorse of the space program and is laying the foundation for human missions to the moon and to distant locations that now only robots travel. The lessons learned from this innovative machine and the space program's Apollo heritage have spurred advancements in space transportation concepts that will power the exploration fleet of the future.

The space shuttle will retire in 2010, and its chief purpose until then will be to help finish assembly of the International Space Station (ISS), fulfilling the commitment to our partner countries. Research on board the ISS will help us better understand and overcome the effects of human space flight on astronaut health, increasing the safety of planned future space missions.

The space station's future vital role is evident with the United States' plans for the new manned space exploration vehicle, being developed under NASA's Constellation

Program. The Orion crew exploration vehicle will succeed the space shuttle and have a piloted and robotic cargo capability to the ISS, along with the ability to rendezvous with transportation elements in high Earth orbit.

Orion builds on the success of the Apollo command and lunar modules and benefits from recent advances in propulsion and electronic technologies. Orion will be about three times larger than Apollo and ferry humans to the moon, Mars, and other destinations in our solar system.

Orion is comprised of a crew module, service module, launch abort system, and spacecraft adapter that mounts it to its launch vehicle. The crew module carries a crew of up to six astronauts to the space station or four astronauts to the moon. The service module carries the major support subsystems such as propulsion, avionics, and thermal management. The launch abort system will allow astronauts to escape the launch vehicle and land safely in the event of a launch-related problem.

The entire Orion configuration will launch aboard a new launch system called Ares I.

During lunar missions, Orion will be mated in low Earth orbit with two additional modules: a propulsion module called the Earth departure stage that will allow Orion to travel to lunar orbit, and a lunar lander. Once in lunar orbit, the lunar lander will separate from Orion and carry astronauts to the lunar surface. Orion, meanwhile, will orbit the moon autonomously for up to 6 months while its crew explores the lunar surface.

The realization of extended human stays on the moon, like the opportunity Orion provides, is already helping fuel dialogue among private industry about commercial lunar venture opportunities.

Lunar commerce reflects industry's desire to compete. Free market competition generates products and services that bolster consumer interest and global economies, so a partnership between NASA and private industry for lunar services could bring appreciable benefits on Earth.

If frozen water is found on the moon, for example, a company could be involved in extracting the elements of the compound as a means to manufacture rocket fuel on the moon. The fuel could power vehicles headed beyond the moon towards Mars, lowering space exploration costs.

Additionally, advertising and branding activities would abound. Video cameras on robotic spacecraft could beam high-definition imagery down to Earth for use in publicizing company products and services. Media opportunities for producing documentaries and other movie-making activities would also be possible—all steering the public's gaze toward space and the science, math, and engineering leading us there.

In the vastness of space, like all great frontiers, there is the potential to extend humankind's knowledge far beyond what our imaginations can theorize. Thus, exploration and discovery are key agents of growth in society and can only lead to the nation's technological, economic, social, international, and intellectual advancement. The accomplishments of current and past U.S. space explorers are a potent symbol of what the human spirit can achieve.

BUILDING THE FUTURE OF FLIGHT TOGETHER

From their common beginnings as builders of biplanes to the exploration of space, Boeing, North American, and McDonnell Douglas share a unique aerospace heritage. Today, as one company, Boeing continues to pioneer the exploration of space.

As the Space Age dawned, each company translated its aeronautical expertise into humankind's greatest engineering feat—sending astronauts to the moon and returning them safely to Earth.

Following the success of the Apollo program, the companies continued working together in space.

When North American Rockwell began developing six space shuttles, Boeing and McDonnell Douglas joined as key partners.

McDonnell Douglas developed aft propulsion pods to control the shuttle while in orbit. It also provided structural parts for the boosters that lift shuttles into space.

Boeing modified two 747 jetliners to piggyback shuttles from landing sites in California to launch pads in Florida. One of the jumbo jets also helped test the first shuttle, which was released from the 747 at an altitude of 22,800 feet before gliding to a perfect landing.

In addition, Boeing developed the Inertial Upper Stage used by shuttle crews to boost satellites into higher orbits.

The shuttle fleet has been transporting humans and cargo to space since 1981 and has completed more than 114 missions. Innovations in the shuttle's design, such as a "glass cockpit," much like ones in modern airliners, improve safety and performance.

Even before the mergers, McDonnell Douglas and Boeing were part of the Boeing-led program to develop the International Space Station. They produced key components, including the massive solar panels, the U.S. Laboratory "Destiny," and the truss that forms the station's structural backbone.

Since then, Boeing was named NASA's lead contractor for the ISS. This includes design to delivery of U.S.-built elements. Boeing is also the major subcontractor to United Space Alliance for NASA's Space Flight Operations Contract. Boeing is responsible for sustaining engineering support to operations throughout all missions. Additionally, the Boeing team provides overall shuttle system and payload integration services, and launch and mission support.

Once completed, the million-pound space station will include six laboratories and have an internal volume roughly equivalent to the passenger cabin of 1.5 747 jumbo jets. The orbital research facility recently completed its sixth year of continuous human presence.

BOEING AND THE SPACE SHUTTLE

In addition to manufacturing the space shuttle, The Boeing Company also plays a multitude of behind-the-scene roles integral to NASA's human space flight program.

Boeing's Space Exploration, a unit of Boeing Integrated Defense Systems, which is headquartered in St. Louis, performs the work. Space Exploration is headquartered in Houston and also operates facilities in Huntington Beach, Calif.; Huntsville, Ala.; Kennedy Space Center, Fla.; and Palmdale, Calif.

Boeing is the major subcontractor to United Space Alliance (USA), NASA's prime contractor for space shuttle operations. USA is a leader in space operations, offering extensive experience in space launch and recovery operations; mission planning and control; flight hardware processing; space flight training; on-orbit assembly, payload deployment and servicing; rendezvous/proximity operations and docking; and large-scale integration and sustaining engineering. USA provides operations services for the ISS and employs more than 10,000 people in Texas, Florida, and Alabama.

Boeing has provided design engineering and support for the shuttle fleet since the first flight in 1981. Boeing engineers are actively involved in the design and development work required to fulfill America's space vision, using the existing shuttle experience and knowledge as a stepping-stone to the next space exploration vehicle.

Boeing's space shuttle work is organized into the following areas:

Ongoing Engineering Support: Boeing serves as the technical expert to NASA and USA on the design and operations of the orbiter fleet to ensure its continued safety, flight readiness, efficiency, and overall mission success. Activities range from designing new system modifications and upgrades to resolving day to day issues and mission anomalies.

System and Payload Integration: Boeing identifies overall shuttle system (orbiter, Space Shuttle Main Engines, external tank, and solid rocket boosters) and payload requirements during all shuttle operations phases: ground operations and checkout, ascent, on orbit operations, reentry, landing, and ferry flight activities. It also ensures the complementary operation of shuttle system elements, payloads, and ground systems. Activities range from evaluating external structural loads, aerodynamics, heating, and guidance to developing payload support hardware.

Orbiter Maintenance and Modifications: A technical team at Kennedy Space Center supports periodic orbiter major modifications, during which each vehicle receives a comprehensive structural inspection and modifications designed to reduce program maintenance costs, expand shuttle mission capabilities, and improve operations, safety, and reliability.

Payload Ground Operations: Under the Checkout, Assembly, and Payload Processing Contract at NASA's Kennedy Space Center, Boeing performs engineering and facilities support and maintenance activities related to preparing payloads for launch in the shuttle's payload bay. Processing a human space flight payload involves complex scheduling and logistics and precise testing to ensure the payload can communicate with the orbiter and ground stations. The payloads can include scientific instruments, interplanetary spacecraft, research laboratory modules, and elements of the International Space Station. Processing activities begin years before a mission is scheduled to fly; the advance time depends on the mission's complexity.

Boeing Contributions to Space Shuttle Return-to-Flight Missions STS-114 and STS-121

With responsibility for the space shuttle orbiter and integration of its key elements, Boeing played a major role in key Return-to-Flight tasks, including:

- Conducting debris impact testing to quantify the impact damage resistance capabilities of the orbiter.
- Determining the aerodynamic effect of removing foam ramps from the space shuttle's external fuel tank. In July 2005, Discovery lost a sizeable piece of foam from the protuberance air load (PAL) ramp, a protective ramp designed to smooth the airflow over cable trays and pressure lines during launch.
- Improving orbiter TPS components, including wing panels and heat-resistive tiles, to further protect the vehicle from debris impacts.
- Determining a way to prevent gap fillers, thin spacers between the space shuttle's heat resistant tiles, from protruding from the belly of the orbiter.
- Designing and manufacturing hardware for the orbiter boom sensor system (OBSS) used by astronauts to inspect the space shuttle during the mission.
- Developing on-orbit repair capabilities should there be debris damage during a space shuttle flight.
- Replacing windows in the orbiter with ones better able to handle aerodynamic loads during ascent.
- Evaluating the effects of tin whiskering in avionics boxes, a phenomenon where tin, typically in a plated application, spontaneously develops threadlike growths from its surface.
- Assisting with the troubleshooting efforts that helped narrow down a malfunctioning engine cut-off (ECO) sensor in the ET.
- Conducting exhaustive research to evaluate the impact of shuttle design and operational changes to ensure there are no unintended consequences.

SPACE SHUTTLE FACTS

LENGTH

System:	184.2 ft
Orbiter:	122.17 ft
External Tank:	153.8 ft
Solid Rocket Boosters (SRBs):	149.16 ft

HEIGHT

System:	76.6 ft
Orbiter:	56.58 ft

WINGSPAN

Orbiter:	78.06 ft

WEIGHT

Gross Lift-Off:	4,500,000 lb
Orbiter Landing:	Varies, dependent upon mission

ORBITER DRY WEIGHT (WITH THREE SPACE SHUTTLE MAIN ENGINES)

Discovery:	176,419 lb
Atlantis:	176,413 lb
Endeavour:	176,056 lb
External Tank (Full):	1,658,900 lb
External Tank (Inert):	58,500 lb
SRBs (2), Each at Launch:	1,298,500 lb
SRB Inert Weight, Each:	186,800 lb

THRUST

SRBs (2):
3,300,000 lb of thrust each in a vacuum

Space Shuttle Main Engines (3):
418,000 lb of thrust each at sea level at 109 percent

CARGO BAY

Dimensions:
60-ft long, 15 ft in diameter

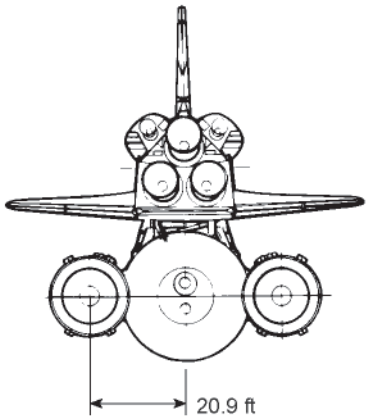
Payloads:
Unmanned spacecraft to fully equipped scientific laboratories and ISS elements

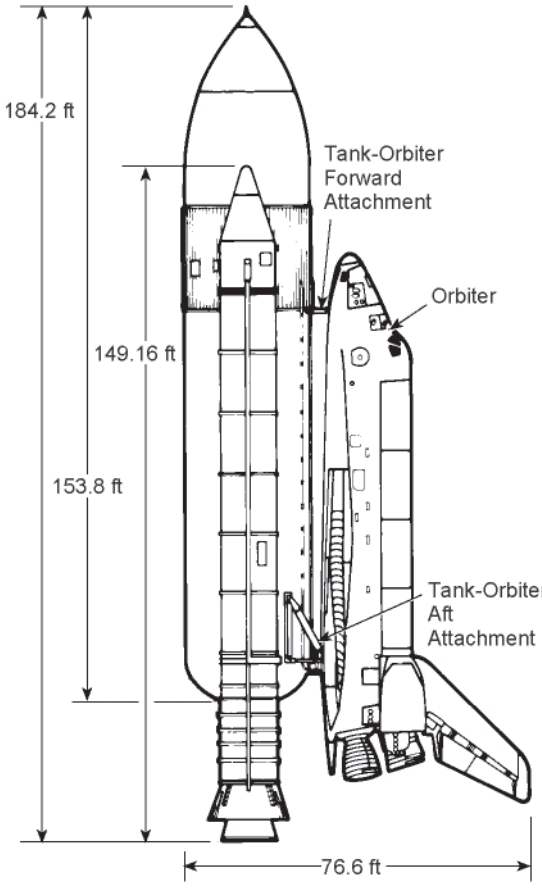
PERFORMANCE

Payload for 160 nmi Orbit	
Due East (28.5°)—Discovery, Atlantis, or Endeavour:	54,000 lb*
High Inclination (51.6°)—Discovery, Atlantis, or Endeavour:	36,200 lb*

(weights approximate)

*Includes: Managers' reserve, payload attach hardware, and flight support equipment





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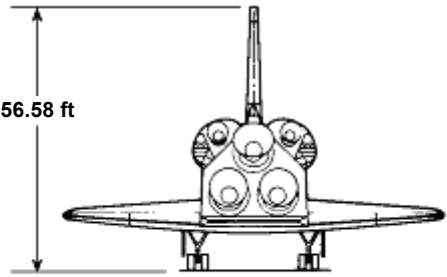

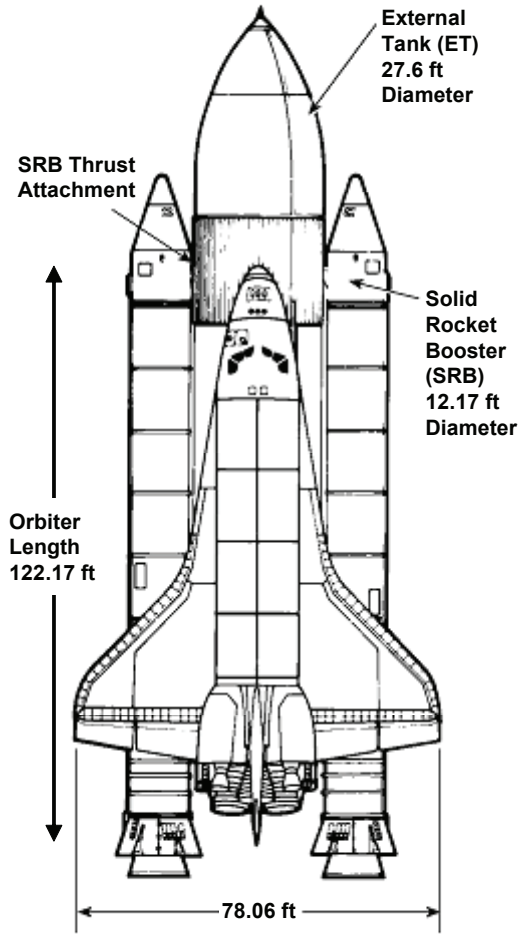

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Space Shuttle Main Engine (SSME)

The Space Shuttle Main Engines are the most reliable and highly tested large rocket engines ever built. The SSMEs operate at greater temperature extremes than any mechanical system in common use today. At -423°F, the engine's fuel, liquefied hydrogen, is the second coldest liquid on Earth. When it and the liquid oxygen are combined and combusted, the temperature in the main combustion chamber is 6,000°F, hotter than the boiling point of iron.

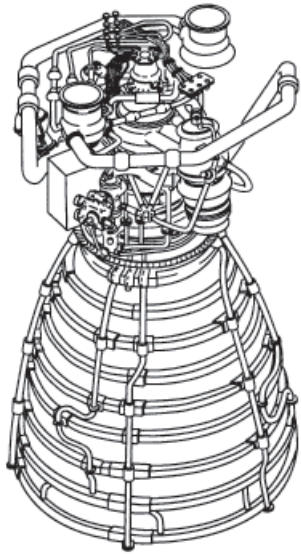
One SSME generates enough thrust to maintain the flight of 2.5 Boeing 747s. Some 64,000 gallons of fuel are consumed by the main engines each minute. Even though an SSME weighs one-seventh as much as a locomotive engine, its high-pressure fuel pump alone delivers as much horsepower as 28 locomotives, while its high-pressure oxidizer pump delivers the equivalent horsepower of an additional 11 locomotives. The maximum equivalent horsepower developed by the three main engines is more than 37,000,000 horsepower.

The Space Shuttle Main Engines are built by Pratt & Whitney Rocketdyne, a business unit of United Technologies. Development of the engines began in the early 1970s and first flew in 1981. Since that time, the SSME remains the only reusable large rocket engine rated for human space flight in the world, with several having logged as many as 19 missions. It is also the most efficient engine in the world, with an efficiency rating—or Isp—of 452.3 seconds.

PERFORMANCE

BLOCK II SSME (FULL-POWER LEVEL)

MAXIMUM THRUST (109% POWER LEVEL)	
At Sea Level:	418,000 lb
In Vacuum:	512,300 lb
THROTTLE RANGE:	67–109 percent
PRESSURES:	
Hydrogen Pump Discharge:	6,276 psia
Oxygen Pump Discharge:	7,268 psia
Chamber Pressure:	2,994 psia
SPECIFIC IMPULSE (IN VACUUM):	452.3 sec
POWER OF HIGH-PRESSURE PUMPS:	
Hydrogen:	71,140 HP
Oxygen:	23,260 HP
AREA RATIO:	69:1
WEIGHT:	7,774 lb
MIXTURE RATIO (OXIDIZER TO FUEL):	6.03:1
DIMENSIONS:	
Length:	168 in.
Width:	96 in.



Space Shuttle Main Engine

External Tank

The bright orange external tank—standing taller than a 15-story building with a length of 153.8 feet and as wide as a silo with a diameter of 27.6 feet—is the single largest component of the space shuttle and is not reusable.

The ET consists of three tanks: the forward liquid oxygen tank, the aft liquid hydrogen tank, and an unpressurized intertank that unites the two propellant tanks. Weighing 58,500 lb empty and 1,668,500 lb when filled with propellants, the ET supplies more than 535,000 gallons of liquid hydrogen and oxygen to the shuttle's main engines.

The ET is primarily made of a lightweight aluminum-lithium alloy and consists of approximately 481,450 parts. If all the weld joints in the ET were laid out in a straight line, they would stretch more than half a mile. Despite its size, the aluminum skin of the tank is only 0.10-inch thick in most areas.

The ET is covered with a thermal protection system, or spray-on polyurethane-like foam insulation, which, if spread on the ground, would cover nearly two-thirds of an acre. The foam insulation on the majority of the tank is only 1-inch thick. Insulation in the areas of the tank subjected to the highest heating is somewhat thicker—between 1.5- to 3-inches thick.

The closed-cell foam used on the ET was developed to keep the propellants that fuel the shuttle's three main engines at optimum temperature. It keeps the shuttle's liquid hydrogen fuel at -423°F and the liquid oxygen tank at near -297°F—even as the tank sits under the hot Florida sun—while preventing a buildup of ice on the outside of the tank.

A redesigned, safer external tank with its protuberance airloads (PAL) ramps removed successfully flew on the STS-121 mission on July 4, 2006, and the STS-115 mission on Sept. 9, 2006. The retrofitted ET incorporates design and process changes to minimize the size and probability of debris generated during launch and ascent.

The combined volume of the ET's liquid hydrogen and liquid oxygen tanks is 73,600 cubic feet—equal to the volume of nearly six 1,600-square-foot homes. Loading of the propellant takes approximately 3 hours.

During ascent, the ET supplies cryogenic propellants through 17-inch feedlines to the orbiter engines at a rate of 1,035 gallons per second. The ET absorbs most of the 7,000,000 lb of thrust exerted by the solid rocket boosters and the orbiter's main engines. Within 8.5 minutes, the orbiter has reached space, traveling at a rate in excess of 17,500 mph. At that point, the ET separates from the orbiter and most of the tank disintegrates upon reentry into the atmosphere.

External Tank

Lockheed Martin Space Systems–Michoud Operations builds the space shuttle external tank at the NASA Michoud Assembly Facility in New Orleans under contract to the NASA Marshall Space Flight Center in Huntsville, Ala.

Solid Rocket Booster (SRB)

The space shuttle's two solid rocket boosters, the first designed for refurbishment and reuse, are also the largest solid rockets ever built and the first to be flown on a manned spacecraft.

The two SRBs generate a combined thrust of 6,600,000 lb, equivalent to 44,000,000 horsepower or 14,700 six-axle diesel locomotives or 400,000 subcompact cars.

Each of the shuttle's solid rocket boosters burns 5 tons of propellant per second, a total of 1,100,000 lb in 120 seconds. At liftoff, each SRB consumes 11,000 lb of fuel per second. That's two million times the rate at which fuel is burned by the average family car.

If their heat energy could be converted to electric power, two SRBs firing for 2 minutes would produce 2,200,000 kilowatt hours of power, enough to supply the entire power demand of 87,000 homes for a full day.

The speed of the gases exiting the nozzle is more than 6,000 miles per hour, about five times the speed of sound or three times the speed of a high-powered rifle bullet. The combustion gases in an SRB are at a temperature of 6,100°F, two-thirds the temperature of the surface of the Sun. While that temperature is hot enough to boil steel, special insulation inside the motor protects the steel case so well that the outside of the case reaches only about 130°F.

Each of the two SRBs has eight separation motors, which are small solid-fuel rocket motors designed to provide 24,000 lb of thrust each in less than 0.8 second.

The two SRBs provide 71.4 percent of the thrust at liftoff and during first-stage ascent.

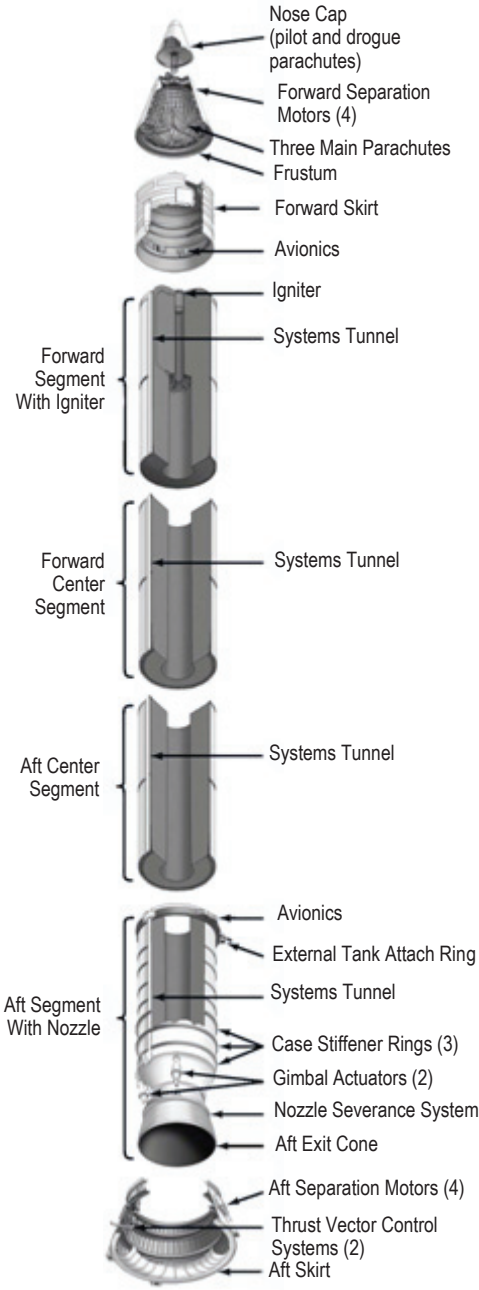
After 2 minutes, at an altitude of about 24 miles, the boosters separate from the ET and descend by parachute approximately 141 miles downrange into the ocean, where they are collected for refurbishment and reuse.

The ATK Launch Systems Group builds the solid rocket boosters at its facility in Promontory, Utah.

Key Components:

The Igniter: The igniter is mounted in the forward end of the SRB. It is approximately 48-inches long and 17 inches in diameter. Containing 134 lb of propellant, the igniter, when electrically activated, spreads flame down the entire length of the solid rocket booster. Approximately 0.34 seconds later, the space shuttle orbiter begins its ascent.

The Motor Case: Consisting of 11 steel sections—nine cylinders, an aft dome, and a forward dome—joined tang to clevis and held together by load-bearing pins, the case is weld-free. Moreover, its segments are reusable—designed to perform safely and predictably for up to 20 launches.



Solid Rocket Booster

The Propellant: When we speak of solid rocket boosters, we are referring to the propellant, which is a solid and has somewhat the same consistency as the eraser on a pencil. The solid propellant used to power the space shuttle is a composition of aluminum powder (the fuel), ammonium perchlorate (the oxidizer), HB polymer (the binder), a measured amount of iron oxide to ensure the desired propellant burn rate, and an epoxy curing agent.

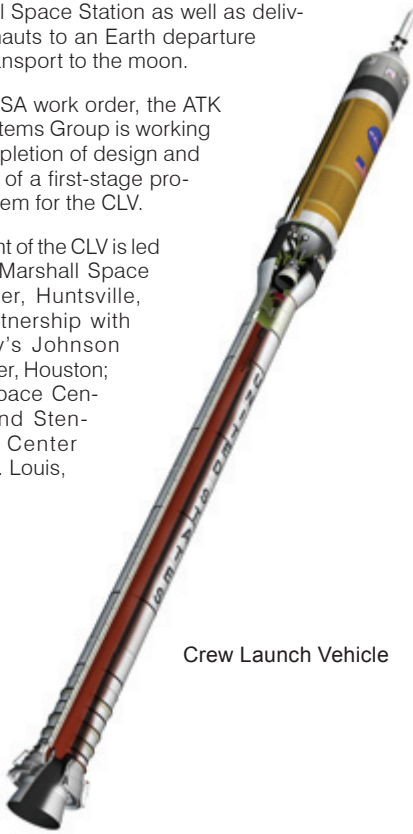
The Nozzle: The nozzle, the point of exit for the hot gases of combustion, is designed to move up to 8 degrees in any direction. This is made possible by the flexible bearing. This capability to direct the booster's thrust is crucial to guiding the orbiter along its proper trajectory until the SRBs separate after liftoff.

Crew Launch Vehicle

NASA's next-generation human launch system, the Ares I Crew Launch Vehicle (CLV), is an in-line, two-stage rocket configuration derived from existing space shuttle solid rocket motor and booster technology. The CLV's primary mission is to carry astronauts and supplies to the International Space Station as well as delivering astronauts to an Earth departure stage for transport to the moon.

Under a NASA work order, the ATK Launch Systems Group is working toward completion of design and certification of a first-stage propulsion system for the CLV.

Development of the CLV is led by NASA's Marshall Space Flight Center, Huntsville, Ala., in partnership with the agency's Johnson Space Center, Houston; Kennedy Space Center, Fla.; and Stennis Space Center near Bay St. Louis, Miss.



Crew Launch Vehicle

Shuttle Amazing Facts

The space shuttle has more than 2,000,000 parts, including about 230 miles of wire, more than 1,060 plumbing valves and connections, about 500 circuit breakers, and more than 24,000 insulating tiles and thermal blankets. It is the most complex machine ever built.

Although it weighs more than 4,500,000 lb at launch, the space shuttle accelerates from zero to about nine times as fast as a rifle bullet, or more than 17,500 miles per hour to attain Earth orbit in 8-1/2 minutes. The shuttle breaks the sound barrier 52 seconds into flight.

The orbiter, both the brains and heart of the Space Transportation System, is about the same size and about 31,000 lb heavier than a Boeing 737 aircraft. The cargo bay measures 60 feet by 15 feet in diameter and can carry cargo equivalent to the size of a school bus.

The shuttle's 24,000 individual tiles are made primarily of pure sand silicate fibers, mixed with a ceramic binder. Incredibly lightweight and about the same density as balsa wood, they dissipate the heat so quickly that a white-hot tile with a temperature of 2,300°F can be taken from an oven and held in bare hands without injury.

Two orbital maneuvering system (OMS) engines, mounted on either side of the upper aft fuselage, provide thrust for major orbital changes. For more exacting motions in orbit, 44 small rocket engines, clustered on the shuttle's nose and on either side of the tail, are used. Together, they are known as the reaction control system.

During re-entry into the Earth's atmosphere and traveling more than 17,000 miles per hour, the space shuttle's exterior temperatures can reach up to 3,000°F.

Since the first flight in 1981, NASA has launched the space shuttle 116 times, carrying two-thirds of the humans to have ever flown in space and accumulating more than 1,284 days of total flight time.

The shuttle fleet has logged more than 425,000,000 miles—well in excess of the distance from the Earth to the Sun and back—and has carried in excess of 3,035,000 lb of cargo and more than 850 major payloads into orbit.

At 149.16 feet tall, the solid rocket booster is only 2 feet shorter than the Statue of Liberty. But each 700-ton loaded booster weighs more than three times as much as the famous statue.

The 15-story tall, rust-colored external tank is the only shuttle element that isn't reused. It feeds more than 500,000 gallons of fuel to the shuttle's main engines during launch.

If the shuttle main engines pumped water instead of fuel, they would drain an average size swimming pool in 25 seconds.

The energy released by the three Space Shuttle Main Engines at their full power—calculated in watts—is equivalent to the same amount of energy created by 13 Hoover Dams.

BOEING AND THE INTERNATIONAL SPACE STATION

In 1993 Boeing was selected as prime contractor for the ISS. With a "space footprint" larger than the size of a football field, the ISS is the largest international space venture ever undertaken. Boeing directs a national industry team comprising many major U.S. aerospace companies and hundreds of smaller subcontractors.

Operations

The Boeing Houston team leads the program's efforts on the ISS contract. U.S. segments include the U.S. Laboratory, interconnecting nodes and structures, power system, data management system, environmental control and life support system, and other critical hardware and software. The team also technically integrates the elements provided by other countries.

Marshall Space Flight Center in Huntsville, Ala., was the production site of Boeing work on the space station's pressurized U.S. modules, including Node 1, the U.S. Laboratory, and the airlock. The Huntsville team also designed the station's environmental control and life support system. Other space station work includes building payload racks, cargo carriers, internal thermal controls, internal audio-video system, a secondary power subsystem, and other subsystems.

Boeing Rocketdyne Propulsion & Power in Canoga Park, Calif., developed the end-to-end electrical power system architecture for the ISS. The system provides all user and housekeeping electrical power and is capable of expansion as the station is assembled. Flexible, deployable solar array wings provide power for the space station. Each wing consists of two blanket assemblies covered with solar cells. Each pair of blankets was deployed and is supported by an extendable mast. In August 2005, United Technologies Corporation (UTC) acquired Rocketdyne, which was combined with Pratt & Whitney's Space Propulsion division, and now operates as Pratt & Whitney Rocketdyne, a wholly owned subsidiary of UTC.

The Boeing Huntington Beach, Calif., team developed and built the station's preintegrated truss structure, pressurized mating adapters, and mobile transporter. Huntington Beach also led several teams in development of various systems, such as communications and tracking; guidance, navigation, and control; command and data handling; and thermal control.

Boeing provides continuing mission operations support and sustaining engineering for the ISS vehicle.

The Value of ISS

The work performed by expedition crews has proven to be indispensable in its value to the advancement of science, human space exploration, and international cooperation.

Key objectives and accomplishments include:

- The ISS is the only platform for learning how to live and work for extended missions in space.
- Expedition crews conduct science daily across a wide variety of fields including human life sciences, physical sciences, and Earth observation, as well as education and technology demonstrations.
- Research on the station is advancing medicine, industry, and basic sciences on Earth.
- Our partnership with 15 other nations will aid international cooperation in future exploration missions.
- The ISS is absolutely vital to human exploration. It's where we're learning how to combat the physiological effects of being in space for long periods of time. ISS is the testbed for technologies and decision-making processes when things go as planned and even when they don't.

Research on ISS

The ISS is a world-class, state-of-the-art, multipurpose laboratory that provides an unprecedented gateway to scientific and technological discovery. The crew members who work and live on this permanent orbiting science and technology research base are devoting themselves to carrying out investigations that exploit the station's unique microgravity environment. From the inception of ISS science, research has been conducted in a diverse array of disciplines, from life and microgravity science studies to Earth science and space science research. In support of the Vision for Space Exploration, ISS science focuses on investigations that will lead to better understanding of the impacts on humans of long-duration space flight in preparation for future expeditions to the moon and to Mars.

Space investigators from industry, academia, and government will take advantage of a rich diversity of facilities carried aboard the orbiting complex. In addition, "remote telescience"—meaning an interactive set of data and video links—offers the ability for scientists on the ground to have a direct connection with their experiments in microgravity.

Research is under way on board ISS on an ongoing basis, yielding a steady stream of findings that are important to our understanding of humans in space and that also increase our understanding of Earth-bound human systems. For example, studies related to bone density loss associated with long-duration space flight are applicable to studies of osteoporosis and aging. New technologies needed for future exploration missions—including new materials, life support systems, and environmental monitoring—are being tested on the station. New scientific results from early space station research, from basic science to exploration research, are being published every month.

ISS science facilities are comprised of racks and subracks that hold scientific experiments of common disciplines. ISS will eventually provide 8 research racks, 16 system racks, and 10 stowage racks to support the conduct of experiments. The active rack isolation system has been effective in further isolating ISS equipment and ISS activities from the experiment racks to provide the desired levels of microgravity that make the station environment for experimentation so unique. Key science facilities that are already on board or are planned for upcoming logistics missions include:

- 5 EXPRESS racks, housing smaller experiments for multidiscipline use
- Human Research Facility-1 (HRF-1)
- Human Research Facility-2 (HRF-2)

ISS FACTS
(weights approximate)

Measurements (at completion)

Solar Array Wingspan:	356 ft (108.5 m) (port to starboard)
Length:	167 ft (51.0 m) (pressurized section)
Integrated Truss Length:	310 ft (94.5 m)
Mass (weight):	925,627 lb (419,857 kg)
Operating Altitude:	220 nmi average (407 km)
Inclination:	51.6 deg to the Equator
Atmosphere Inside:	14.7 psi (101.36 kilopascals), same as Earth
Pressurized Volume:	33,023 ft^3 (935 m^3) (assumes a Soyuz and Progress vehicle are docked to station)
Crew Size:	Six
Speed:	17,500 mph
Robotic Arms:	55-ft robot arm assembly that can lift 220,000 lb and is used for assembly of main ISS; 30-ft robotic arm based on Kibo and used to move and deploy experiments on the Japanese External Facility
Power Generation:	75 to 110 kilowatts

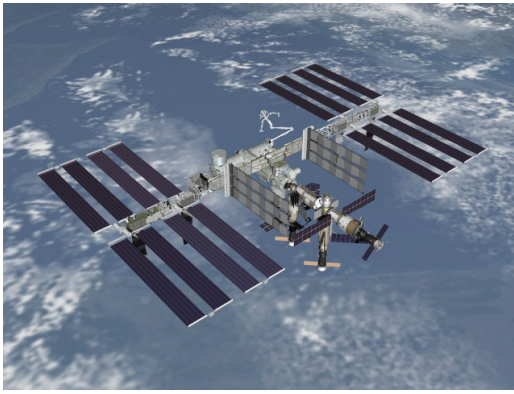
The Partners

16 countries have come together to build ISS:

- Belgium
- Brazil
- Canada
- Denmark
- France
- Germany
- Italy
- Japan
- Netherlands
- Norway
- Russia
- Spain
- Sweden
- Switzerland
- United Kingdom
- United States

ISS Configuration as of Mission STS-115/ISS-12A (September 2006)

Final ISS Configuration



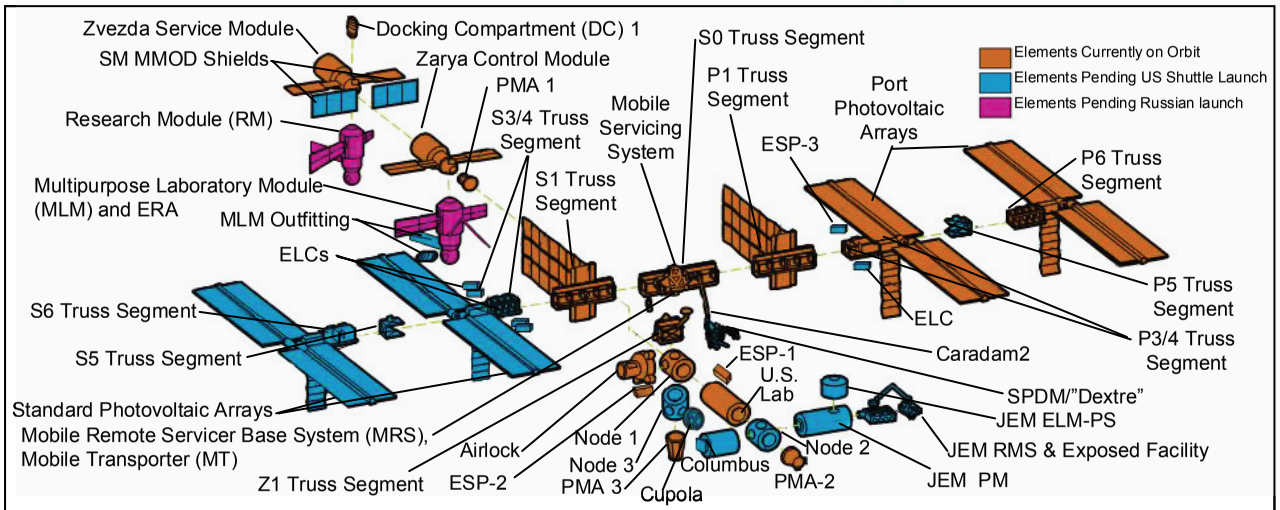
ISS Element Statistics (as of November 2006)

Module	Weight (lb)	Weight (kg)	Launched
Zarya	54,949	24,924	11/20/98
Unity	26,389	11,970	12/04/98
PMA 1	3,504	1,589	12/04/98
PMA 2	3,033	1,376	12/04/98
Zvezda	54,172	24,572	07/12/00
Z1 Truss	19,451	8,823	10/11/00
PMA 3	2,575	1,168	10/11/00
Soyuz	15,762	7,150	
P6 Truss	36,751	16,670	11/30/00
Destiny	54,325	24,641	02/07/01
External Stowage Platform 1	145	66	03/08/01
Canadarm2	3,311	1,502	04/19/01
Quest	21,877	9,923	07/12/01
Progress	15,760	7,149	
Pirs	8,461	3,838	09/15/01
S0 Truss	24,940	11,313	04/08/02
Mobile Base System	5,025	2,280	06/05/02
S1 Truss	27,191	12,334	10/07/02
CETA-A	540	245	10/07/02
P1 Truss	27,005	12,249	11/23/02
CETA-B	540	245	11/23/02
External Stowage Platform 2	6,336	2,874	07/26/05
P3/P4 Truss	34,868	15,816	09/09/06
Current Total:	**171 ft long; 240 ft wide; 90 ft high; 215 tons of mass**		

ISS Elements to Be Added

P5 Truss	4,101 lb (1,860 kg)
S3/S4 Truss	35,662 lb (16,176 kg)
S5 Truss	4,040 lb (1,833 kg)
S6 Truss	30,433 lb (13,804 kg)
Node 2	29,848 lb (13,539 kg)
Columbus Science Laboratory	29,458 lb (13,362 kg)
Multipurpose Laboratory Module	44,754 lb (20,300 kg)
JEM	35,726 lb (16,205 kg)
Node 3	33,551 lb (15,218 kg)
Kibo	33,000 lb (14,969 kg)
Cupola	3,732 lb (1,693 kg)
Starboard Rails (MT/CETA Port)	6,655 lb (3,019 kg)
Russian Research Module	42,000 lb (19,051 kg)

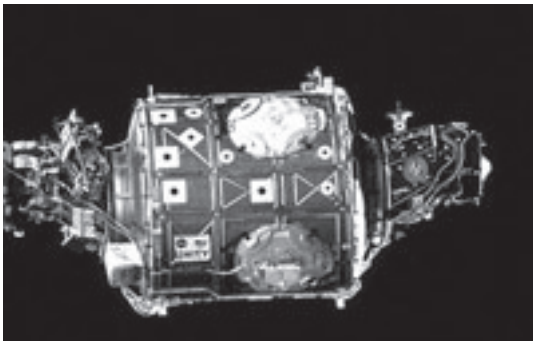
Final ISS Configuration



ISS Elements on Orbit

Node 1

Node 1 was the first U.S.-built component of the ISS, a cylinder-shaped connecting module with six passageways, or nodes, to which future modules will be attached.



ISS Node 1, "Unity" Module, and Two Pressurized Mating Adapters (PMAs) During Space Shuttle Mission STS-88/ ISS-2A

Length:	18 ft (5.49 m)
Width:	15 ft (4.57 m)
Weight:	26,389 lb (11,970 kg)

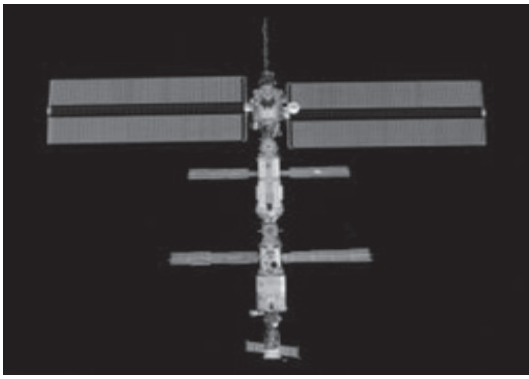
Pressurized Mating Adapters (PMAs)

Conical docking adapters, called pressurized mating adapters (PMAs), allow the docking systems used by the space shuttle and by Russian modules to attach to the ISS. One PMA permanently attaches Node 1 to Zarya, while another is moved during assembly to provide a shuttle docking port as the ISS grows.

Length:	7 ft (2.13 m)
Diameter:	5 ft (1.5 m) at one end, 9 ft (2.74 m) at the other
Material:	Aluminum pressure shell with an aluminum debris shield

P6 Truss—Solar Array

The U.S.-made photovoltaic solar arrays attached to the P6 truss segment use purified silicon solar cells to directly convert light to electricity, which allows the crew to live comfortably, to safely operate the station, and to perform scientific experiments.



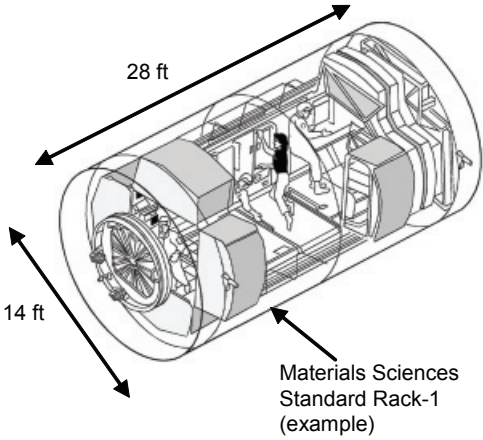
ISS After Installation of P6 Truss on Space Shuttle Mission STS-97/ISS-4A

Length:	240 ft (73.2 m)
Width:	35 ft (10.7 m)
Weight:	36,751 lb (16,670 kg)

U.S. Laboratory "Destiny"

Length:	28 ft (8.5 m)
Width:	14 ft (4.3 m)
Weight:	54,325 lb (24,641 kg)
Volume:	3,750 ft^3 (106 m^3)
Windows:	1 - 20 in. (50.9 cm)
No. of Racks:	24 (13 scientific and 11 system)
Exterior:	Aluminum "waffle" pattern, covered with an insulation blanket and intermediate debris shield)
Delivered:	Space shuttle mission STS-98/ISS-5A
Provided:	First ISS science module

U.S. Laboratory "Destiny" Configuration



Rack Facts

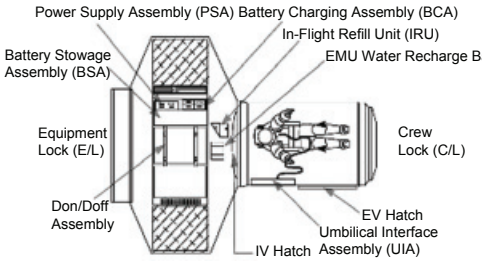
Height:	73 in. (1.9 m)
Width:	42 in. (1.1 m)
Weight:	1,200 lb (544 kg)
Exterior:	Graphite composite shell

Joint Airlock "Quest"

The Joint Airlock module, which has the capability to be used by both Russian and U.S. spacesuit designs, consists of two sections, a crew lock that is used to exit the station and begin a spacewalk, and an equipment lock used for storing gear.

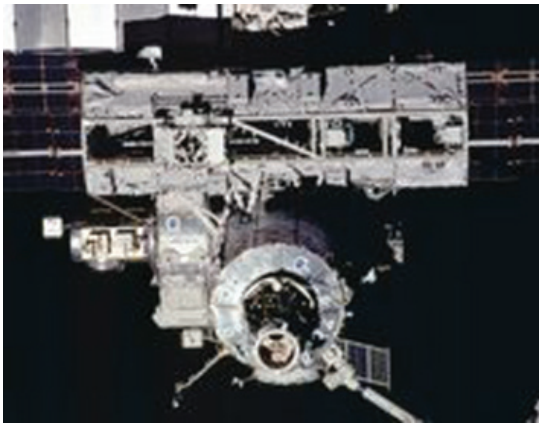
Length:	18 ft (5.5 m)
Diameter:	13 ft (4 m)
Weight:	21,877 lb (9,923 kg)
Volume:	1,200 ft^3 (34 m^3)
Material:	Aluminum, covered with insulation blankets and intermediate debris shields
Number of racks:	Two systems racks
Delivered:	Space shuttle mission STS-104/ISS-7A

Joint Airlock "Quest" Configuration



Starboard 0 (S0) Truss

The Central Integrated Truss (Starboard 0) forms the center backbone of the ISS. It is attached to the U.S. Laboratory and is used to route power to the pressurized station modules and conduct heat away from the modules to the S1 and P1 trusses. The truss segments were numbered in ascending order outward to the port and starboard sides. At one time, an S2 and P2 were planned but were eliminated when the station design was scaled back. From S0, the truss segments are P1, P3, P4, P5, and P6; and S1, S3, S4, S5, and S6.



Central Integrated Truss (S0) Following Installation During Space Shuttle Mission STS-110/ISS-8A

Length:	44 ft (13.4 m)
Width:	15 ft (4.6 m)
Weight:	24,940 lb (11,313 kg)

Starboard 1 and Port 1 Trusses

The S1 and P1 trusses are attached to the S0 truss and contain rails upon which the mobile base system and crew equipment carts can transport the Canadarm2 and astronauts to work sites along the space station.

S1 Truss Being Installed During Space Shuttle Mission STS-112/ISS-9A

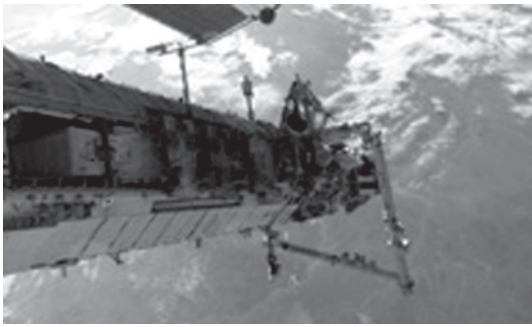
Length:	45 ft (13.7 m)
Width:	15 ft (4.6 m)
Weight:	27,191 lb (12,334 kg)

P1 Truss Being Installed During Space Shuttle Mission STS-113/ISS-11A

Length:	45 ft (13.7 m)
Width:	15 ft (4.6 m)
Weight:	27,005 lb (12,249 kg)

Port 3 and 4 Trusses

The P3 and P4 trusses are attached to the P1 truss and provide an attachment point for P5. The P3 and P4 trusses also provide a second set of solar array wings (SAWs) and the first alpha joint. Each solar wing, deployed in opposite directions from each other, is 115 ft by 38 ft. The segments support utility routing, power distribution, and a translation path for the mobile base system (MBS). Major P3 subsystems include the segment-to-segment attach system (SSAS), solar alpha rotary joint (SARJ), and unpressurized cargo carrier attach system (UCCAS). Major P4 subsystems include the photovoltaic radiator (PVR), alpha joint interface structure (AJIS), modified Rocketdyne truss attachment system (MRTAS), and integrated equipment assembly (IEA).



P3/P4 Truss Being Installed During Space Shuttle Mission STS-115/ISS-12A

Length:	44 ft, 10 in. (13.7 m)
Width:	16 ft, 4 in. (5 m)
Weight:	34,885 lb (15,824 kg)

With the P4 element, NASA has deployed the first external wireless instrumentation system (EWIS). The system consists of accelerometers placed around the outboard integrated truss structure. The vibration data seen by the accelerometers will be compared with their loads models so they can be further refined by engineers with actual on-orbit data to better predict the fatigue life and durability of the station's integrated truss structure. This wireless system supplements 33 hard-wired accelerometers currently installed on the inboard truss elements (S0, S1, S3, P1, and P3).

ISS Electrical Power System

During STS-116, spacewalking astronauts will perform the equivalent of rewiring the station's Electrical Power System (EPS). The astronauts, along with Boeing engineers and NASA mission controllers, will orchestrate a precise ballet of powering down equipment, transferring it over to other redundant power channels, and then unplugging and plugging in electrical connectors.

The ISS power system will transition from its temporary system to its permanent configuration by rerouting power through electrical components on its Port 1, Starboard 0, and Starboard 1 trusses for the first time.

Like a city's central power plant, the station's giant solar arrays generate primary ISS power at levels too high for consumer use, ranging from 137 to 173 Vdc. The power is regulated between 150 to 160 volts, then routed to batteries for storage and to switching units that route it to distribution networks. The power coming from the solar arrays and batteries is called primary power.

The primary power is routed to the four main bus switching units located on the S0 truss. The MBSUs are fed by eight independent power channels (corresponding to each of the eight solar array wings), and the MBSUs output all ISS loads. Under normal operations, each power channel supplies power to a specific set of loads. However, if that channel fails, the MBSUs enable feeding power to those loads from another channel, which greatly enhances the fault tolerance of the EPS.

DC-to-DC converters "step-down" the primary 160-Vdc electricity to a more tightly regulated secondary power of 124.5 Vdc and distribute it to individual users. On Main Street USA, the users would be shops and homes. On the ISS, they are laboratories, living quarters, and the like. This secondary power feeds all the loads on the station. Most "electronics" such as laptops within the labs, nodes, airlocks, and living areas use even lower voltage stepped down via power supplies.

The space shuttle and most other spacecraft operate at 28 Vdc, as does the Russian ISS segment, which has its own two sets of solar arrays but can use and share U.S. power by using converters. The higher voltage of the U.S. power system will meet the higher overall ISS requirements for research as a test power bed for exploration while permitting use of smaller, lighter weight power lines. The higher voltage also reduces ohmic power losses through the wires.

Even though the station will spend about one-third of every orbit in the Earth's shadow, the electrical power system will continuously provide 84 kW of usable power to ISS systems and users once all eight solar array wings are on orbit. Boeing's Rocketdyne Propulsion and Power division (now Pratt & Whitney Rocketdyne) built most of the EPS hardware. Boeing, along with Pratt & Whitney Rocketdyne as a subcontractor, provides EPS sustaining engineering support to NASA.

Active Thermal Control System Overview

Most of the station's many systems produce waste heat, which needs to be transferred from the ISS to space to achieve thermal control and maintain electrical compo-

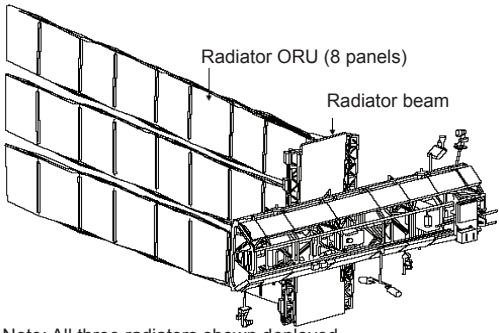
nents at acceptable temperatures. An Active Thermal Control System (ATCS) is required to achieve this heat rejection function when the combination of the ISS external environment and the generated heat loads exceeds the capabilities of the Passive Thermal Control System to maintain temperatures. An ATCS uses a mechanically pumped fluid in closed-loop circuits to perform three functions: heat collection, heat transportation, and heat rejection. Waste heat is removed in two ways: through coldplates and heat exchangers, both of which are cooled by circulating ammonia loops on the outside of the station. Ammonia is used because of its low freezing point. The heated ammonia circulates through large radiators located on the exterior of the ISS, releasing the heat by radiation to space that cools the ammonia as it flows through the radiators.

The ATCS consists of the Internal Active Thermal Control System (IATCS), External Active Thermal Control System (EATCS), Photovoltaic Thermal Control System (PVTCS), and Early External Active Thermal Control System (EEATCS). The IATCS consists of loops that circulate water through the interior of the U.S. Laboratory module to collect the excess heat from electronic and experiment equipment and distributes this heat to the interface heat exchangers for transfer to the EATCS. At assembly complete, there will be nine separate ITCS water loops in the U.S. and international partner pressurized modules.

The Photovoltaic Thermal Control System (PVTCS) consists of ammonia loops that collect excess heat from the Electrical Power System (EPS) components in the Integrated Equipment Assembly (IEA) on P4 and eventually S4 and transport this heat to the PV radiators (located on P4, P6, S4, and S6) where it is rejected to space. The PVTCS consists of ammonia coolant, 11 coldplates, two pump flow control subassemblies (PFCS), and one photovoltaic radiator (PVR).

The External Active Thermal Control System (EATCS), activated for the first time on this mission, consists of ammonia loops to collect heat from the interface heat exchangers and external electronic equipment mounted on coldplates and transports it to the S1 and P1 radiators where it is rejected to space. In lieu of using the EATCS initially, the station hardware has been cooled by the Early External Active Thermal Control System (EEATCS). The EEATCS has provided heat rejection capability rejection capability for the U.S. Laboratory interface heat exchangers (IFHX) from assembly flight 5A through 12A.1.

The EEATCS is the temporary system used to collect, transport, and reject waste heat from habitable volumes on the station. The EEATCS collects heat from the IFHX located on the U.S. Laboratory module, circulates the working fluid, anhydrous ammonia, via the pump and flow control subassembly (PFCS), and rejects heat to space via two orthogonally oriented stationary radiators.



Note: All three radiators shown deployed.

ISS Flights to Date

1A/R:	Nov. 20, 1998
Launch Vehicle:	Russian Proton rocket
Elements:	Zarya control module (Functional Cargo Block—FGB)
Provided:	Early propulsion, power, fuel storage, communications
Current Duties:	Passageway, stowage facility, docking port, fuel tank
2A/STS-88:	Dec. 4, 1998
Launch Vehicle:	Space shuttle Endeavour
Elements:	Unity Node; two pressurized mating adapters
Provided:	Unity—connecting points for Z1 truss/U.S. Laboratory; PMA-1—connects U.S. and Russian elements; PMA-2—shuttle docking location
Future Duties:	Connecting point for airlock, cupola, Node 3, Multi-Purpose Logistics Module, control module
2A.1/STS-96:	May 27, 1999
Launch Vehicle:	Space shuttle Discovery
Elements:	SPACEHAB; logistics flight
Provided:	Resupply cargo; external Russian cargo crane used for spacewalking maintenance activities
2A.2a/STS-101:	May 19, 2000
Launch Vehicle:	Space shuttle Atlantis
Elements:	SPACEHAB double cargo module
Provided:	Internal logistics and resupply cargo. Four of six batteries were swapped to restore the electrical power system to full redundancy
1R:	July 12, 2000
Launch Vehicle:	Russian Proton rocket
Elements:	Zvezda service module
Provided:	Early station living quarters, life support, propulsive attitude control and reboost capability; docking port for Progress-type cargo resupply vehicles and Soyuz vehicles
2A.2b/STS-106:	Sept. 8, 2000
Launch Vehicle:	Space shuttle Atlantis
Elements:	SPACEHAB double cargo module
Provided:	Unloaded supplies from Progress; battery and voltage converter installation; connected power, data, and communications cables between the Zvezda and Zarya; installed treadmill; delivered toilet

3A/STS-92:	Oct. 11, 2000
Launch Vehicle:	Space shuttle Discovery
Elements:	Integrated truss structure (ITS) Z1, Pressurized Mating Adapter-3 (PMA), Ku-band communications system, control moment gyros (CMGs)
Provided:	Z1 as early framework for first U.S. solar arrays (power); Ku-band communication system (science capability and U.S. television); nonpropulsive, electrically powered attitude control with CMG; PMA-3 provided shuttle docking port for solar array installation
2R:	Oct. 31, 2000
Launch Vehicle:	Russian Soyuz
Elements:	Expedition 1 Crew
Established:	First permanent human presence in space with three-person crew: commander Bill Shepherd, Soyuz commander Yuri Gidzenko, flight engineer Sergei Krikalev. Crew on board for 4 months; relieved by Expedition 2 crew on STS-102
Activities:	Performed flight test, checked out communications systems, charged batteries for power tools, started water processors, activated life support systems, began scientific experiments
4A/STS-97:	Nov. 30, 2000
Launch Vehicle:	Space shuttle Endeavour
Elements:	Integrated truss structure P6, photovoltaic module, radiators
Provided:	First U.S. solar power with solar arrays and batteries (photovoltaic module), two radiators for early cooling, S-band communications system activated for voice and telemetry
5A/STS-98:	Feb. 7, 2001
Launch Vehicle:	Space shuttle Atlantis
Elements:	U.S. Laboratory “Destiny”
Provided:	Destiny is the centerpiece of ISS, where unprecedented science experiments will be performed. It contains five system racks and provides initial U.S. user capability. Control moment gyroscopes activated for electrically powered attitude control

5A.1/STS-102:	March 8, 2001
Launch Vehicle:	Space shuttle Discovery
Elements:	Leonardo Multi-Purpose Logistics Module (MPLM) carried equipment racks
Provided:	Logistics and resupply; pressurized MPLMs served as station's "moving vans" and will carry new laboratory racks filled with equipment, experiments and supplies and return old racks and experiments to Earth
Established:	Second resident crew, Expedition 2, to the station: commander Yury Usachev and flight engineers James Voss and Susan Helms. Returned Expedition 1 crew to Earth
6A/STS-100:	April 19, 2001
Launch Vehicle:	Space shuttle Endeavour
Elements:	Raffaello MPLM carried equipment racks; ultra-high frequency (UHF) antenna; Space Station Remote Manipulator System (SSRMS)
Provided:	Installation, activation and checkout of the SSRMS robotic arm (Canadarm2), which is critical to the continuing assembly of the ISS
7A/STS-104:	July 12, 2001
Launch Vehicle:	Space shuttle Atlantis
Elements:	Joint airlock "Quest"; high-pressure gas tanks (two oxygen and two nitrogen) installed on the airlock
Provided:	Installation, checkout and first use of the joint airlock, which will support the use of either U.S. spacesuits or Russian Orlan spacesuits during spacewalks
7A.1/STS-105:	Aug. 14, 2001
Launch Vehicle:	Space shuttle Discovery
Elements:	Leonardo MPLM carried equipment racks
Provided:	Logistics and resupply
Established:	Third resident crew, Expedition 3, to the station: commander Frank Culbertson and flight engineers Vladimir Dezhurov and Mikhail Tyurin. Returned Expedition 2 crew to Earth

UF-1/STS-108:	Dec. 5, 2001
Launch Vehicle:	Space shuttle Endeavour
Elements:	Raffaello MPLM carried equipment racks, STARSHINE 2 satellite
Established:	Fourth resident crew, Expedition 4, to the station: commander Yuri Onufrienko and flight engineers Daniel Bursch and Carl Walz. Returned Expedition 3 crew to Earth
8A/STS-110:	April 8, 2002
Launch Vehicle:	Space shuttle Atlantis
Elements:	Starboard-zero (S0) central integrated truss structure; mobile transporter, which will be attached to the mobile base system during mission STS-111 to create the first "railroad in space"
UF-2/STS-111:	June 5, 2002
Launch Vehicle:	Space shuttle Endeavour
Elements:	Leonardo MPLM carried equipment racks; mobile base system (MBS)
Provided:	Repaired wrist roll joint on Canadarm2; installed MBS to mobile transporter, previously delivered on STS-110, which completes the Mobile Servicing System. The Mobile Servicing System will provide greater mobility to Canadarm2, allow the transport of payloads across the ISS, and aid the crew in spacewalks
Established:	Fifth resident crew, Expedition 5, to the station: commander Valery Korzun and flight engineers Peggy Whitson and Sergei Treschev. Returned Expedition 4 crew to Earth. Expedition 4 crewmembers Carl Walz and Daniel Bursch set new record for longest U.S. space flight (196 days), breaking the previous record of 188 days in space held by Shannon Lucid aboard the Russian space station Mir. Walz now also holds the U.S. record for the most cumulative time in space with 231 days.
9A/STS-112:	Oct. 7, 2002
Launch Vehicle:	Space shuttle Atlantis
Elements:	Starboard-one (S1) truss
Provided:	The S1 truss contains a new external cooling system for the station that will be activated next year;

	also, a second S-band communications system to provide enhanced and extended voice and data capability; the Crew and Equipment Translation Aid (CETA) cart that will serve as a mobile work platform for future spacewalkers; two new external television cameras; and the first thermal radiator rotary joint (TRRJ), which will provide the mechanical and electrical energy for rotating the station's heat-rejecting radiators. The S1 truss will enable the station to begin the outboard expansion of its rail system in preparation for the addition of new power and science modules in the years to come.
11A/STS-113:	Nov. 23, 2002
Launch Vehicle:	Space shuttle Endeavour
Elements:	Port-one (P1) truss and Crew and Equipment Translation Aid (CETA) cart
Provided:	The P1 truss, which is preintegrated with ultra-high frequency (UHF) communication equipment, thermal radiator rotary joint (TRRJ), three external active thermal control system (EATCS) radiators, direct current (DC)-to-DC converter unit (DDCU), remote power controller module (RPCM), nitrogen tank assembly (NTA), ammonia tank assembly (ATA), and pump module assembly (PMA)
Established:	Sixth resident crew, Expedition 6, to the station: commander Kenneth Bowersox, flight engineer Nikolai Budarin, and science officer Donald Pettit. Returned Expedition 5 crew to Earth
LF1/STS-114:	July 26, 2005
Launch Vehicle:	Space shuttle Discovery
Elements:	Raffaello MPLM carried equipment racks
Provided:	Test of orbiter boom sensor system (OBSS), test and evaluation of thermal protection system (TPS) repair techniques, replaced one ISS control gyroscope and restored power to a second gyroscope, installed work platform on ISS for future construction

ULF1.1/STS-121:	July 4, 2006
Launch Vehicle:	Space shuttle Discovery
Elements:	Leonardo MPLM carried equipment racks
Provided:	Additional test of orbiter boom sensor system (OBSS), additional test and evaluation of thermal protection system (TPS) repair techniques, replaced trailing umbilical system–reel assembly (TUS-RA) to restore station's mobile robotic system to full operation
Re-established:	Three-person ISS crew for the first time since May 2003
12A/STS-115:	Sept. 9, 2006
Launch Vehicle:	Space shuttle Atlantis
Elements:	P3/P4 truss
Provided:	The P3 and P4 trusses are attached to the P1 truss and provide an attachment point for P5. The P3 and P4 trusses also provide a second set of solar array wings (SAWs) and the first alpha joint. The segments support utility routing, power distribution, and a translation path for the mobile base system (MBS). Major P3 subsystems include the segment-to-segment attach system (SSAS), solar alpha rotary joint (SARJ), and unpressurized cargo carrier attach system (UCCAS). Major P4 subsystems include the photovoltaic radiator (PVR), alpha joint interface structure (AJIS), modified Rocketdyne truss attachment system (MRTAS), and integrated equipment assembly (IEA).

Extravehicular Mobility Unit

The space shuttle and ISS extravehicular mobility unit (EMU), or spacesuit, has dramatically enabled humans to work effectively in space. Extravehicular activity (EVA), or spacewalk, highlights include the refueling and repair of satellites on orbit, retrieval of satellites for refurbishment on Earth, and the assembly of the ISS. The EMU has and will continue to play a vital role in allowing America's space shuttle to fulfill a wide spectrum of space tasks such as inspection, maintenance, repair, construction, and, if necessary, rescue operations.

Hamilton Sundstrand Space Systems International provides the EMU for NASA. The 394-lb EMU is modularized to fit astronauts and serves as a one-person spacecraft, providing protection and Earth-like mobility for EVA astronauts. It is constructed of a urethane-coated nylon pressure bladder; orthofabric and aluminized mylar thermal/meteoroid garment; fiberglass hard upper torso; ball-bearing joints (arm, wrist, leg); and polycarbonate helmet and visors. It provides a suit operating pressure of 4.3 psid in an operating environment ranging from 0 psia to 14.7 psia for up to 7 hours.

Spacesuit assembly (SSA) provides:

- Atmosphere containment
- High-mobility and low-torque body joints
- Thermal insulation
- Cooling distribution
- Waste collection
- Sunlight and solar radiation protection
- Micrometeoroid and debris protection
- Simple on-orbit resizing capability

Life Support System (LSS) provides:

- Oxygen supply
- Suit pressurization and ventilation
- Communications
- Breathing gas purification
- Temperature control

- Independent emergency life support for up to 30 minutes
- Orbital Replaceable Unit (ORU) capability

For safety, the EMU is constantly monitored by a Caution and Warning System (CWS), which monitors 17 sensors, contaminant levels, and remaining expendables such as oxygen, water, and power.

EVAs (as of November 2006)

Flight	No. of EVAs	Duration
STS-88	3	21 hr, 22 min
STS-96	1	7 hr, 55 min
STS-101	1	6 hr, 44 min
STS-106	1	6 hr, 14 min
STS-92	4	27 hr, 19 min
STS-97	3	19 hr, 20 min
STS-98	3	19 hr, 49 min
STS-102	2	15 hr, 17 min
STS-100	2	14 hr, 50 min
STS-104	2	12 hr, 29 min
STS-105	2	11 hr, 45 min
STS-108	1	4 hr, 12 min
STS-114	3	20 hr, 05 min
STS-121	3	21 hr, 29 min
STS-115	3	20 hr, 19 min
Total shuttle-based	28	187 hr, 21 min
Total ISS-based	44	251 hr, 16 min
Total to date	**72**	**438 hr, 37 min**

Future ISS Assembly Schedule (subject to change)

Date	Assembly Flight	Launch Vehicle	Element(s)
No earlier than Dec. 7, 2006	12A.1	Discovery (OV-103) STS-116	• Third port truss segment (ITS P5) • SPACEHAB single cargo module • Integrated Cargo Carrier (ICC)
No earlier than March 16, 2007	13A	Atlantis (OV-104) STS-117	• Second starboard truss segment (ITS S3/S4) with Photovoltaic Radiator (PVR) • Third set of solar arrays and batteries
No earlier than May 1, 2007	ATV1	Ariane 5	• European Automated Transfer Vehicle
No earlier than June 28, 2007	13A.1	Endeavour (OV-105) STS-118	• SPACEHAB single cargo module • Third starboard truss segment (ITS S5) • External Stowage Platform 3 (ESP3) • CMG replacement
No earlier than Sept. 7, 2007	10A	Atlantis (OV-104) STS-120	• Node 2 • Sidewall – Power and Data Grapple Fixture (PDGF)
No earlier than Oct. 2007	1E	Discovery (OV-103) STS-122	• Columbus European Laboratory Module • ICC–Lite
No earlier than Dec. 2007	1J/A	Endeavour (OV-105) STS-123	• Kibo Japanese Experiment Module – Logistics Module (JEM-ELM) • Spacelab Pallet – Deployable 1 (SLP-D1) with Canadian Special Purpose Dexterous Manipulator, Dextre
No earlier than Feb. 2008	1J	Atlantis (OV-104) STS-124	• Kibo Japanese Experiment Module – Pressurized Module (JEM-PM) • Kibo Japanese Experiment Module – Remote Manipulator System JEM-RMS)
No earlier than June 2008	15A	Endeavour (OV-105)	• Fourth starboard truss segment (ITS S6) • Fourth set of solar arrays and batteries
No earlier than Aug. 2008	ULF2	Atlantis (OV-104) STS-126	• Multi-Purpose Logistics Module (MPLM) Leonardo • Last scheduled flight of Atlantis (OV-104)

Date	Assembly Flight	Launch Vehicle	Element(s)
No earlier than Oct. 2008	2J/A	Discovery (OV-103) STS-127	• Kibo Japanese Experiment Module - Exposed Facility (JEM-EF) • Kibo Japanese Experiment Module - Exposed Section (JEM-ES) • Spacelab Pallet - Deployable 2 (SLP-D2)
No earlier than Dec. 2008	3R	Russian Proton	• Russian Multi-Purpose Laboratory Module with European Robotic Arm (ERA)
No earlier than Jan. 2009	17A	Endeavour (OV-105) STS-128	• Multi-Purpose Logistics Module (MPLM) Donatello • Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC) • Three crew quarters, galley, second treadmill (TVIS2), Crew Health Care System 2 (CHeCS 2) • Six-person ISS crew established
Establish Six-Person Crew Capability			
No earlier than Feb. 2008	HTV-1	H-IIA	• Japanese H-II Transfer Vehicle
No earlier than April 2009	ULF3	Discovery (OV-103) STS-129	• EXPRESS Logistics Carrier 1 (ELC1) • EXPRESS Logistics Carrier 2 (ELC2) • Last scheduled flight of Discovery (OV-103)
No earlier than July 2009	19A	Endeavour (OV-105) STS-130	• Multi-Purpose Logistics Module (MPLM) Raffaello • Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC)
No earlier than Oct. 2009	*ULF4	Discovery (OV-103) STS-131	• EXPRESS Logistics Carrier 3 (ELC3) • EXPRESS Logistics Carrier 4 (ELC4)
No earlier than Jan. 2010	20A	Endeavour (OV-105) STS-132	• Node 3 with Cupola • Last scheduled flight of Endeavour (OV-105)
No earlier than July 2010	*ULF5	Endeavour (OV-105) STS-133	• EXPRESS Logistics Carrier 5 (ELC5) • EXPRESS Logistics Carrier 1 (ELC1)

Date	Assembly Flight	Launch Vehicle	Element(s)
ISS Assembly Complete			
Under review	9R	Russian Proton	• Research Module

* Two shuttle-equivalent flights for contingency

Notes: Additional Progress and Soyuz flights for crew transport, logistics, and resupply are not listed. Hubble Servicing Mission is scheduled for no earlier than spring 2008 on STS-125, Discovery (OV-103).

EXPEDITION CREWS

Human space flight history continues to be written each day aboard the International Space Station with the continued human presence of each Expedition crew.

ISS began a new era in exploration by allowing humans to take up permanent residence in space. Many questions about how to sustain life in outer space were previously answered during NASA's experience with the Shuttle/Mir program. This knowledge, combined with the discoveries of the astronauts and cosmonauts living on board ISS, will greatly increase our understanding of what it is like living in space.

While human life is permanently present on the station, the crews rotate during crew exchange flights. During the hand-over period, the current space station crewmembers communicate by telecon to the new crewmembers any rare situations they have dealt with, any new techniques they have learned, or any information that might be helpful to the new residents. Once the new crewmembers actually arrive, the outgoing crew will brief them on safety, vehicle changes, and payload operations.

The current habitable pressurized volume on ISS—15,000 cubic feet (425 cubic meters)—is equal to the habitable space in a 1,800-square-foot (167-square-meter) three-bedroom house with 8-foot (2.4-meter) ceilings. The habitable pressurized volume on the completed station will be 34,700 cubic feet (983 cubic meters), roughly equivalent to the interior of a Boeing 747.

Expedition 1

Mission:	ISS Flight 2R
Vehicle:	Soyuz
Launched:	Oct. 31, 2000, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Bill Shepherd Soyuz commander Yuri Gidzenko Flight engineer Sergei Krikalev
Returned:	March 21, 2001, aboard STS-102 (Discovery)
Duration:	141 days

Expedition 2

Mission:	STS-102/ISS Flight 5A.1
Vehicle:	Space shuttle Discovery
Launched:	March 8, 2001, from Kennedy Space Center, Pad 39B
Crew:	ISS commander Yury Usachev Flight engineer James Voss Flight engineer Susan Helms
Returned:	Aug. 22, 2001, aboard STS-105 (Discovery)
Duration:	167 days

Expedition 3

Mission:	STS-105/ISS Flight 7A.1
Vehicle:	Space shuttle Discovery
Launched:	Aug. 10, 2001, from Kennedy Space Center, Pad 39A
Crew:	ISS commander Frank Culbertson Jr., Soyuz commander Vladimir Dezhurov Flight engineer Mikhail Tyurin
Returned:	Dec. 17, 2001, aboard STS-108 (Endeavour)
Duration:	129 days

Expedition 4

Mission:	STS-108/ISS Flight UF-1
Vehicle:	Space shuttle Endeavour
Launched:	Dec. 5, 2001, from Kennedy Space Center, Pad 39B
Crew:	ISS commander Yury I. Onufrienko Flight engineer Daniel W. Bursch Flight engineer Carl E. Walz
Returned:	June 19, 2002, aboard STS-111 (Endeavour)
Duration:	196 days

Expedition 5

Mission:	STS-111/ISS Flight UF-2
Vehicle:	Space shuttle Endeavour
Launched:	June 5, 2002, from Kennedy Space Center, Pad 39A
Crew:	ISS commander Valery G. Korzun ISS science officer Peggy A. Whitson Flight engineer Sergei Y. Treschev
Returned:	Dec. 7, 2002, aboard STS-113 (Endeavour)
Duration:	185 days

Expedition 6

Mission:	STS-113/ISS Flight 11A
Vehicle:	Space shuttle Endeavour
Launched:	Nov. 23, 2002, from Kennedy Space Center, Pad 39A
Crew:	ISS commander Kenneth D. Bowersox Flight engineer Nikolai M. Budarin ISS science officer Donald R. Pettit
Returned:	May 3, 2003, aboard Soyuz TMA-1
Duration:	161 days

Expedition 7

Vehicle:	Soyuz TMA-2
Launched:	April 25, 2003, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Yuri I. Malenchenko Flight engineer/science officer Edward T. Lu
Returned:	Oct. 27, 2003, aboard Soyuz TMA-2
Duration:	185 days

Expedition 8

Vehicle:	Soyuz TMA-3
Launched:	Oct. 18, 2003, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander/science officer C. Michael Foale Flight engineer Alexander Y. Kaleri Flight engineer Pedro Duque (launched with Expedition 8, returned with Expedition 7)
Returned:	April 29, 2004, aboard Soyuz TMA-3
Duration:	195 days

Expedition 9

Vehicle:	Soyuz TMA-4
Launched:	April 18, 2004, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Gennady I. Padalka Flight engineer/science officer E. Michael Fincke Flight engineer André Kuipers (launched with Expedition 9, returned with Expedition 8)
Returned:	Oct. 23, 2004, aboard Soyuz TMA-4
Duration:	188 days

Expedition 10

Vehicle:	Soyuz TMA-5
Launched:	Oct. 13, 2004, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander/science officer Leroy Chiao Flight engineer Salizhan S. Sharipov Flight engineer Yuri G. Shargin (launched with Expedition 10, returned with Expedition 9)
Returned:	April 24, 2005, aboard Soyuz TMA-5
Duration:	193 days

Expedition 11

Vehicle:	Soyuz TMA-6
Launched:	April 14, 2005, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Sergei K. Krikalev Flight engineer/science officer John L. Phillips Flight engineer Roberto Vittori (launched with Expedition 11, returned with Expedition 10)
Returned:	Oct. 10, 2005, aboard Soyuz TMA-6
Duration:	179 days

Expedition 12

Vehicle:	TMA-7
Launched:	Sept. 30, 2005, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander/science officer William McArthur Flight engineer Valery Tokarev
Returned:	April 8, 2005, aboard Soyuz TMA-7
Duration:	190 days

Expedition 13

Vehicle:	Soyuz TMA-8
Launched:	March 29, 2006, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander/Soyuz commander Pavel Vinogradov Flight engineer/science officer Jeffrey Williams Flight engineer Marcus Pontes (launched with Expedition 13, returned with Expedition 12) Flight engineer Thomas Reiter (launched aboard STS-121; return aboard STS-116
Returned:	Sept. 28, 2006, aboard Soyuz TMA-8
Duration:	183 days

Expedition 14

Vehicle:	Soyuz TMA-9
Launched:	Sept. 18, 2006, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Michael E. Lopez-Alegria Flight engineer Mikhail Tyurin Flight engineer Thomas Reiter (launched aboard STS-121; return aboard STS-116) Flight engineer Sunita L. Williams (launch aboard STS-116; return aboard STS-118)
Projected Return:	March 2007

Expedition 15

Vehicle:	Soyuz TMA-10
Projected Launch:	March 2007, from Baikonur Cosmodrome in Kazakhstan
Crew:	ISS commander Fyodor N. Yurchikhin Flight engineer Oleg V. Kotov Flight engineer Sunita L. Williams (launch aboard STS-116; return aboard STS-118) Flight engineer Clayton C. Anderson (launch aboard STS-118; return aboard STS-120) Flight engineer Daniel M. Tani (launch aboard STS-120; return aboard STS-122)
Projected Return:	September 2007

INTERESTING ISS FACTS

Astronauts, cosmonauts, and space flight participants from 11 nations have visited the International Space Station or lived aboard the station as Expedition crewmembers. The nations represented are the United States, Russia, Canada, Italy, France, Japan, South Africa, Belgium, Spain, the Netherlands, and Brazil.

More than 25,000 meals and 23,000 snacks (45,000 pounds of food) have been consumed by resident and visiting crews.

Approximately 4 tons of supplies are required to support three crewmembers for 6 months.

The ISS travels an equivalent distance to the Moon and back in about a day.

In a 24-hour period, the ISS orbits Earth 16 times.

The ISS systems are controlled by nearly 4 million lines of software code, about half provided by the United States in core computers and laptops and the balance from Russia and Canada, controlling their systems. Still to be added are another 2.5 million lines of code controlling the European and Japanese modules.

More than 100 telephone booth-size rack facilities will be installed in the ISS for operating the spacecraft systems and research experiments.

The Mobile Servicing System—the mobile transporter and a rail line that will eventually stretch along the structural backbone of the ISS—serves as a mobile base from which the station's robotic arm can assemble and maintain the complex. The mobile transporter has a top speed of 300 feet per hour. Astronauts can operate a small handcar—the Crew and Equipment Translation Aid—to move themselves and their gear from place to place.

The 55-foot station robot arm is able to lift 220,000 pounds, the weight of a space shuttle orbiter.

The ISS will be about four times as large as the Russian space station Mir and about five times as large as the U.S. Skylab.

The ISS effort involves more than 100,000 people in space agencies and at 500 contractor facilities in 37 U.S. states and in 16 countries.

Building the ISS in space is like trying to change a spark plug or hang a shelf while wearing roller skates and two pairs of ski gloves with all your tools, screws, and materials tethered to your body so they don't drop.

Living and working on the ISS is like building one room of a house, moving in a family of three, and asking them to finish building the house while working full-time from home.

STEPPING-STONES AND BRIDGES: FROM MERCURY TO THE ISS

MERCURY/ ATLAS 6	SPACE SHUTTLE	ISS
Length: 6 ft, 10 in.	122 ft	171 ft
Width: 6 ft, $2^{-1/2}$ in.	78 ft (wingspan)	240 ft (solar arrays)
Height: N/A	56 ft	90 ft
Volume: 50 ft^3	2,600 ft^3	15,000 ft^3
Weight: 3,500 lb	200,000 lb	454,000 lb
Computers: 0	5-10 (incl. P/L laptops)	52 (incl. P/L laptops
Flight: 4 hr, 55 min., 23 sec	12 days (avg)	95 months and counting

STS-1 Mission Facts — Columbia —
April 12–14, 1981

Commander: John W. Young
Pilot: Robert Crippen
Mission Duration: 54 hours, 20 minutes, 32 seconds
Miles Traveled: Approximately 1,074,567 statute miles
Inclination: 40 degrees
Orbits of Earth: 36
Orbital Altitude: 145 nautical miles (166 statute miles)
Landing Touchdown: 6,053 feet beyond planned touchdown point
Landing Rollout: 8,993 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 195,472 pounds
Landing Speed at Main Gear Touchdown: 183 knots (210 mph)
Lift-off Weight: Approximately 4,457,111 pounds
Orbiter Weight at Lift-off: Approximately 219,258 pounds
Cargo Weight Up and Down: Approximately 10,823 pounds
Landed: Runway 23 dry lake bed at Edwards Air Force Base, California
Payloads: Development Flight Instrumentation and Aerodynamic Coefficient Identification Package

STS-2 Mission Facts — Columbia —
November 12–14, 1981

Commander: Joe Engle
Pilot: Richard Truly
Mission Duration: 54 hours, 13 minutes, 13 seconds
Miles Traveled: Approximately 1,074,567 statute miles
Inclination: 38 degrees
Orbits of Earth: 36
Orbital Altitude: 137 nautical miles (157 statute miles)
Landing Touchdown: Approximately 780 feet beyond planned touchdown point
Landing Rollout: Approximately 7,711 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 204,262 pounds
Landing Speed at Main Gear Touchdown: Approximately 197 knots (226 miles per hour)
Lift-off Weight: Approximately 4,470,308 pounds
Orbiter Weight at Lift-off: Approximately 230,708 pounds
Cargo Weight Up and Down: Approximately 18,778 pounds
Landed: Runway 23 dry lake bed at Edwards Air Force Base, California

STS-2 Mission Facts (Cont)

Payloads: Office of Space and Terrestrial Applications (OSTA)-1 experiments, Orbiter Experiments (OEX)

STS-3 Mission Facts — Columbia — March 22–30, 1982

Commander: Jack Lousma
Pilot: Gordon Fullerton
Mission Duration: 192 hours (8 days), 4 minutes, 45 seconds
Miles Traveled: Approximately 4.4 million miles
Inclination: 38 degrees
Orbits of Earth: 129
Orbital Altitude: 128 nautical miles (147 statute miles)
Landing Touchdown: Approximately 1,092 feet from threshold
Landing Rollout: Approximately 13,737 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 207,072 pounds
Landing Speed at Main Gear Touchdown: Approximately 220 knots (253 miles per hour)
Lift-off Weight: Approximately 4,468,755 pounds
Orbiter Weight at Lift-off: Approximately 235,415 pounds
Cargo Weight Up and Down: Approximately 22,710 pounds
Landed: Runway 17 dry lake bed at White Sands Missile Range, New Mexico
Payloads: Office of Space Science (OSS) experiments, Monodisperse Latex Reactor (MLR), Electrophoresis Verification Test (EEVT), Plant Lignification Experiment

STS-4 Mission Facts — Columbia — June 27–July 4, 1982

Commander: Ken Mattingly
Pilot: Henry Hartsfield
Mission Duration: 168 hours (7 days), 1 hour, 9 minutes, 40 seconds
Miles Traveled: Approximately 3.3 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 112
Orbital Altitude: 160 nautical miles (184 statute miles), then to 172 nautical miles (197 statute miles)
Landing Touchdown: Approximately 948 feet from threshold
Landing Rollout: Approximately 9,878 feet from main gear touchdown

STS-4 Mission Facts (Cont)

Orbiter Weight at Landing: Approximately 208,946 pounds

Landing Speed at Main Gear Touchdown: Approximately 204 knots (234 miles per hour)

Lift-off Weight: Approximately 4,481,935 pounds

Orbiter Weight at Lift-off: Approximately 241,664 pounds

Cargo Weight Up and Down: Approximately 24,492 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Payloads: Induced Environment Contamination Monitor (IECM), Monodisperse Latex Reactor (MLR), Continuous Flow Electrophoresis System (CFES), Development Flight Instrumentation (DFI), Orbiter Experiments (OEX), first NASA getaway special (GAS), Night/Day Optical Survey of Lightning (NOSL) experiment, Vapor Phase Compression (VPC) freezer heat exchanger dynamics for freezing samples, Aerodynamic Coefficient Identification Package (ACIP) experiment

STS-5 Mission Facts — Columbia — November 11–16, 1982

Commander: Vance D. Brand

Pilot: Robert F. Overmyer

Mission Specialist: Joseph P. Allen

Mission Specialist: William B. Lenoir

Mission Duration: 120 hours (5 days), 2 hours, 14 minutes, 26 seconds

Miles Traveled: 2,110,849 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 81

Orbital Altitude: 160 nautical miles (184 statute miles)

Landing Touchdown: Approximately 1,637 feet from threshold

Landing Rollout: Approximately 9,553 feet from main gear touchdown

Orbiter Weight at Landing: 202,480 pounds

Landing Speed at Main Gear Touchdown: Approximately 198 knots (227 miles per hour)

Lift-off Weight: Approximately 4,487,268 pounds

Orbiter Weight at Lift-off: Approximately 247,113 pounds

Cargo Weight Up: Approximately 32,080 pounds

Cargo Weight Down: Approximately 17,495 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Payloads: First mission to deploy commercial communications satellites: Satellite Business Systems (SBS)-C with Payload Assist Module

STS-5 Mission Facts (Cont)

(PAM)-D; Telesat-E (Canadian communications satellite) with PAM-D. Monodisperse Latex Reactor (MLR), Continuous Flow Electrophoresis System (CFES), three getaway specials (GAS), Student experiments, GLOW experiment, Vestibular experiment, Oxygen Interaction With Materials experiment

STS-6 Mission Facts — Challenger — April 4–9, 1983

Commander: Paul Weitz
Pilot: Karol Bobko
Mission Specialist: Donald Peterson
Mission Specialist: Story Musgrave
Mission Duration: 120 hours (5 days), 23 minutes, 42 seconds
Miles Traveled: 2,094,293 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 80
Orbital Altitude: 155 nautical miles (178 statute miles)
Extravehicular Activity: Story Musgrave and Donald Peterson, duration 3 hours and 54 minutes
Landing Touchdown: Approximately 2,026 feet beyond threshold
Landing Rollout: Approximately 7,180 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 190,330 pounds
Landing Speed at Main Gear Touchdown: Approximately 190 knots (218 miles per hour)
Lift-off Weight: Approximately 4,487,255 pounds
Orbiter Weight at Lift-off: Approximately 256,744 pounds
Cargo Weight Up: Approximately 46,971 pounds
Cargo Weight Down: Approximately 9,425 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Deployment of Tracking and Data Relay Satellite (TDRS)-A with Inertial Upper Stage (IUS)-2, Continuous Flow Electrophoresis System (CFES), Monodisperse Latex Reactor (MLR), Night/Day Optical Survey of Lightning (NOSL) experiment, three getaway specials (GAS)

STS-7 Mission Facts — Challenger — June 18–24, 1983

Commander: Robert L. Crippen
Pilot: Frederick H. Hauck
Mission Specialist: Sally K. Ride

STS-7 Mission Facts (Cont)

Mission Specialist: John M. Fabian
Mission Specialist: Norman E. Thagard
Mission Duration: 144 hours (6 days), 2 hours, 23 minutes, 59 seconds
Miles Traveled: 2,530,567 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 97
Orbital Altitude: 160 nautical miles (184 statute miles) to 160 by 165 nautical miles (184 by 189 statute miles) to 160 by 170 nautical miles (184 by 195 statute miles) to 157 by 170 nautical miles (180 by 195 statute miles) to 157 nautical miles (180 statute miles)
Landing Touchdown: Approximately 2,726 feet beyond threshold
Landing Rollout: Approximately 10,450 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 204,043 pounds
Landing Speed at Main Gear Touchdown: Approximately 202 knots (232 miles per hour)
Lift-off Weight: Approximately 4,482,241 pounds
Orbiter Weight at Lift-off: Approximately 249,178 pounds
Cargo Weight Up: Approximately 37,124 pounds
Cargo Weight Down: Approximately 22,175 pounds
Landed: Runway 15 dry lake bed at Edwards Air Force Base, California
Payloads: Office of Space and Terrestrial Applications (OSTA)-2 experiments, deployment of PALAPA-B1 communications satellite for Indonesia with Payload Assist Module (PAM)-D and Telesat-F communications satellite for Canada with PAM-D, German Shuttle Pallet Satellite (SPAS)-01, seven getaway specials (GAS), Monodisperse Latex Reactor (MLR), Continuous Flow Electrophoresis System (CFES)

STS-8 Mission Facts — Challenger — August 30–September 5, 1983

Commander: Richard H. Truly
Pilot: Daniel C. Brandenstein
Mission Specialist: Guion S. Bluford, Jr.
Mission Specialist: Dale A. Gardner
Mission Specialist: William E. Thornton
Mission Duration: 144 hours (6 days), 1 hour, 8 minutes, 43 seconds
Miles Traveled: 2,514,478 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 97

STS-8 Mission Facts (Cont)

Orbital Altitude: 160 nautical miles (184 statute miles) to 166 by 160 nautical miles (191 by 184 statute miles) to 166 by 121 nautical miles (191 by 139 statute miles) to 121 nautical miles (139 statute miles)

Landing Touchdown: Approximately 2,793 feet beyond threshold

Landing Rollout: Approximately 9,371 feet from main gear touchdown

Orbiter Weight at Landing: Approximately 203,945 pounds

Landing Speed at Main Gear Touchdown: Approximately 195 knots (224 miles per hour)

Lift-off Weight: Approximately 4,492,074 pounds

Orbiter Weight at Lift-off: Approximately 242,742 pounds

Cargo Weight Up: Approximately 30,076 pounds

Cargo Weight Down: Approximately 22,631 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

First night launch and night landing

Payloads: Deployment of INSAT (India communication satellite) with Payload Assist Module (PAM)-D, Payload Flight Test Article (PFTA)/ Payload Deployment Retrieval System (PDRS), Continuous Flow Electrophoresis (CFES), biomedical experiments. 250,000 express mail envelopes with special cachet for U.S. Postal Service were carried for a first-day cover.

STS-9 Mission Facts — Columbia — November 28–December 8, 1983

Commander: John Young

Pilot: Brewster Shaw

Mission Specialist: Robert Parker

Mission Specialist: Owen Garriott

Payload Specialist: Byron Lichtenberg

Payload Specialist: Ulf Merbold

Mission Duration: 240 hours (10 days), 7 hours, 47 minutes, 24 seconds

Miles Traveled: 4,295,853 statute miles

Inclination: 57 degrees

Orbits of Earth: 166

Orbital Altitude: 135 nautical miles (155 statute miles)

Landing Touchdown: Approximately 1,649 feet beyond planned touchdown point

Landing Rollout: Approximately 8,456 feet from main gear touchdown

Orbiter Weight at Landing: Approximately 220,027 pounds

Landing Speed at Main Gear Touchdown: Approximately 185 knots (212 miles per hour)

STS-9 Mission Facts (Cont)

Lift-off Weight: Approximately 4,503,361 pounds
Orbiter Weight at Lift-off: Approximately 247,619 pounds
Cargo Weight Up and Down: Approximately 33,264 pounds
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
Payload: Spacelab-1 experiments, habitable Spacelab and pallet, carried 71 experiments. The six-man crew was divided into two 12-hour-day red and blue teams to operate experiments. First high-inclination orbit of 57 degrees.

41-B Mission Facts — Challenger — February 3–11, 1984

Commander: Vance Brand
Pilot: Robert Gibson
Mission Specialist: Bruce McCandless
Mission Specialist: Robert Stewart
Mission Specialist: Ronald McNair
Mission Duration: 168 hours (7 days), 23 hours, 15 minutes, 55 seconds
Miles Traveled: Approximately 3,311,379 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 127
Orbital Altitude: 165 nautical miles (189 statute miles), then to 170 by 165 nautical miles (195 by 189 statute miles), then to 176 by 165 nautical miles (202 by 189 statute miles), then to 176 by 155 nautical miles (202 by 178 statute miles), then to 155 by 155 nautical miles (178 by 178 statute miles), then to 152 by 152 nautical miles (174 by 174 statute miles)
Extravehicular Activity (EVA): Bruce McCandless and Robert Stewart. EVA No. 1 duration 5 hours, 35 minutes, EVA No. 2 duration 6 hours, 2 minutes. First flight of the manned maneuvering unit (MMU). Bruce McCandless operating time one hour, 55 minutes; Robert Stewart, 44 minutes
Landing Touchdown: Approximately 1,922 feet beyond runway threshold
Landing Rollout: Approximately 10,815 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 201,238 pounds
Lift-off Weight: Approximately 4,498,443 pounds
Orbiter Weight at Lift-off: Approximately 250,285 pounds
Landing Speed at Main Gear Touchdown: Approximately 196 knots (225 miles per hour)
Cargo Weight Up: Approximately 33,868 pounds

41-B Mission Facts (Cont)

Cargo Weight Down: Approximately 19,005 pounds
Landed: Runway 15 at Kennedy Space Center, Florida
Payloads: PALAPA-B2 (Indonesian communications satellite) with Payload Assist Module (PAM)-D and WESTAR (Western Union communications satellite)-VI with PAM-D deployment. Both satellites were deployed but the PAM-D in each satellite failed to ignite, leaving both satellites in earth orbit. Both satellites were retrieved and returned to earth for renovation on the STS-51-A mission. The manned maneuvering unit (MMU) was tested with extravehicular astronauts as free flyers without tethers as far as 320 feet from the orbiter. Shuttle Pallet Satellite (SPAS)-01 experiments, Monodisperse Latex Reactor (MLR), Isoelectric Focusing Experiment (IEF), Acoustic Containerless Experiment System (ACES), Cinema 360 cameras, five getaway specials (GAS), Aerodynamic Coefficient Identification (ACIP)/High Resolution Accelerometer Package (HIRAP)

41-C Mission Facts (STS-13) — Challenger — April 6–13, 1984

Commander: Robert Crippen
Pilot: Francis (Dick) Scobee
Mission Specialist: Terry Hart
Mission Specialist: James van Hoften
Mission Specialist: George Nelson
Mission Duration: 144 hours (6 days), 23 hours, 40 minutes, 7 seconds
Miles Traveled: 2.87 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 107
Orbital Altitude: Averaged out as approximately 272 nautical miles (313 statute miles) circular orbit
Extravehicular Activity (EVA): James van Hoften and George Nelson. EVA No. 1 duration 2 hours, 59 minutes, EVA No. 2 duration 7 hours, 7 minutes. Manned maneuvering unit (MMU) operating time, George Nelson 42 minutes, James van Hoften 28 minutes
Landing Touchdown: Approximately 1,912 feet beyond planned touchdown threshold point
Landing Rollout: Approximately 8,716 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 196,975 pounds
Lift-off Weight: Approximately 4,508,234 pounds
Orbiter Weight at Lift-off: Approximately 254,329 pounds

41-C Mission Facts (Cont)

Landing Speed at Main Gear Touchdown: Approximately 213 knots (245 miles per hour)
Cargo Weight Up: Approximately 38,266 pounds
Cargo Weight Down: Approximately 16,870 pounds
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
First repair on orbit of a satellite, Solar Maximum Mission, by James van Hoften and George Nelson
Payloads: Solar Maximum Mission (SMM) repair, manned maneuvering unit (MMU) satellite support, deployment of Long-Duration Exposure Facility (LDEF) in earth orbit free drift. LDEF contained 57 experiments and weighed about 22,000 pounds. Cinema 360 and IMAX 70-mm cameras.

41-D Mission Facts (STS-14) — Discovery — August 30–September 5, 1984

Commander: Henry Hartsfield, Jr.
Pilot: Michael Coats
Mission Specialist: Richard Mullane
Mission Specialist: Steven Hawley
Mission Specialist: Judith Resnik
Payload Specialist: Charles Walker
Mission Duration: 144 hours (6 days), 56 minutes, 4 seconds
Miles Traveled: 2.49 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 96
Orbital Altitude: 160 by 160 nautical miles (184 by 184 statute miles), then 160 by 165 nautical miles (184 by189 statute miles), then 160 by 173 nautical miles (184 by 199 statute miles), then to 160 by 179 nautical miles (184 by 205 statute miles), then to 159 by 160 nautical miles (182 by 184 statute miles)
Landing Touchdown: Approximately 2,510 feet beyond touchdown threshold point
Landing Rollout: Approximately 10,275 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 201,674 pounds
Lift-off Weight: Approximately 4,517,534 pounds
Orbiter Weight at Lift-off: Approximately 263,477 pounds
Landing Speed at Main Gear Touchdown: Approximately 200 knots (230 miles per hour)
Cargo Weight Up: Approximately 47,516 pounds
Cargo Weight Down: Approximately 11,296 pounds
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California

41-D Mission Facts (Cont)

Payloads: Satellite Business System (SBS)-D communications satellite with Payload Assist Module (PAM)-D deployment, Syncom IV-2 communications satellite with its unique stage deployment, Telstar (American Telephone and Telegraph) 3-C with PAM-D deployment, Office of Aeronautics and Space Technology (OAST)-1 experiments.

Deployment and restowing of large solar array. Continuous Flow Electrophoresis (CFES). IMAX camera

A student experiment, sponsored by Rockwell International, of indium crystal growth using the float zone technique was successful, although a blown fuse resulted in a premature shutdown.

41-G Mission Facts (STS-17) — Challenger — October 5–13, 1984

Commander: Robert Crippen
Pilot: Jon McBride
Mission Specialist: David Leestma
Mission Specialist: Sally Ride
Mission Specialist: Kathryn Sullivan
Payload Specialist: Paul Scully-Power
Payload Specialist: Marc Garneau
Mission Duration: 192 hours (8 days), 5 hours, 23 minutes, 33 seconds
Miles Traveled: 3,434,444 statute miles
Inclination: 57 degrees
Orbits of Earth: 132
Orbital Altitude: 190 by 190 nautical miles (218 by 218 statute miles), then to 148 by 148 nautical miles (170 by 170 statute miles), then to 120 by 120 nautical miles (138 by 138 statute miles)
Extravehicular Activity (EVA): Kathryn Sullivan and David Leestma. EVA duration 3 hours, 29 minutes
Landing Touchdown: Approximately 959 feet beyond threshold point
Landing Rollout: Approximately 10,633 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 202,266 pounds
Lift-off Weight: Approximately 4,493,317 pounds
Orbiter Weight at Lift-off: Approximately 242,790 pounds
Landing Speed at Main Gear Touchdown: Approximately 208 knots (239 miles per hour)
Cargo Weight Up: Approximately 23,465 pounds
Cargo Weight Down: Approximately 18,516 pounds
Landed: Runway 33 at Kennedy Space Center, Florida

41-G Mission Facts (Cont)

Payloads: Earth Radiation Budget Satellite (ERBS) deployment, Office of Space and Terrestrial Applications (OSTA)-3 experiments, Large Format Camera (LFC)
First use of Orbital Refueling System (ORS) with extravehicular activity (EVA) astronauts, IMAX camera

51-A Mission Facts — Discovery — November 8–16, 1984

Commander: Frederick Hauck
Pilot: David Walker
Mission Specialist: Joseph Allen
Mission Specialist: Anna Fisher
Mission Specialist: Dale Gardner
Mission Duration: 168 hours (7 days), 23 hours, 44 minutes, 56 seconds
Miles Traveled: 3,289,406 statute miles
Inclination: 28.5 degrees
Orbits of Earth: 126
Orbital Altitude: 161 by 151 nautical miles (nmi) (185 by 173 statute miles [sm]), then 161 by 156 nmi (185 by 179 sm), then to 163 by 156 nmi (187 by 179 sm), then to163 by 163 nmi (187 by 187 sm), then to169 by163 nmi (194 by 187 sm), then to 171 by 169 nmi (196 by 194 sm), then to 174 by 169 nmi (200 by 194 sm), then to 178 by 174 nmi (204 by 200 sm), then to 178 by 176 nmi (204 by 202 sm), then to 193 by 176 nmi (222 by 202 sm), then to 193 by 183 nmi (222 by 210 sm), then to 195 by 189 nmi (224 by 217 sm), then to 195 by 191 nmi (224 by 219 sm), then to 193 by 183 nmi (222 by 210 sm), then to 193 by 189 nmi (222 by 217 sm), then to 195 by 190 nmi (224 by 218 sm)
Landing Touchdown: Approximately 2,718 feet beyond threshold point
Landing Rollout: Approximately 9,461 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 207,505 pounds
Lift-off Weight: Approximately 4,519,901 pounds
Orbiter Weight at Lift-off: Approximately 263,324 pounds
Landing Speed at Main Gear Touchdown: Approximately 186 knots (214 miles per hour)
Cargo Weight Up: Approximately 45,306 pounds
Cargo Weight Down: Approximately 24,853 pounds
Landed: Runway 15 at Kennedy Space Center, Florida
First retrieval of two satellites (PALAPA B-2 and WESTAR VI) for return to earth.

51-A Mission Facts (Cont)

Extravehicular Activity (EVA): Joseph Allen and Dale Gardner. EVA No. 1 duration, 6 hours, 13 minutes. EVA No. 2 duration, 6 hours and 1 minute. Manned maneuvering unit (MMU) operating time Joseph Allen 2 hours, 22 minutes, Dale Gardner 1 hour, 40 minutes

Payloads: Telesat (Canada communications satellite)-H with Payload Assist Module (PAM)-D deployment, Syncom IV-1 communications satellite deployment with its unique stage, retrieval of PALAPA B-2 and WESTAR VI communications satellites with PAM-D which failed to ignite on the STS-41-B mission. Manned maneuvering unit (MMU) used for retrieval.

Diffusive Mixing of Organic Solutions (DMOS) experiment

51-C Mission Facts — Discovery — January 24–27, 1985

Commander: Thomas K. Mattingly II

Pilot: Loren J. Shriver

Mission Specialist: Ellison S. Onizuka

Mission Specialist: James F. Buchli

Payload Specialist: Gary E. Payton

Mission Duration: 72 hours (3 days), 1 hour, 33 minutes, 23 seconds

Inclination: 28.45 degrees

Orbits of Earth: 48

Landing Touchdown: Approximately 2,753 feet beyond runway threshold

Landing Rollout: Approximately 7,352 feet

Landing Speed at Main Gear Touchdown: Approximately 185 knots (212 miles per hour)

Landed: Runway 15 at Kennedy Space Center, Florida

Payload: DOD

51-D Mission Facts — Discovery — April 12–19, 1985

Commander: Karol J. Bobko

Pilot: Donald E. Williams

Mission Specialist: Jeffrey A. Hoffman

Mission Specialist: S. David Griggs

Mission Specialist: Margaret Rhea Seddon

Payload Specialist: Charles D. Walker

Payload Specialist: Senator Jake Garn (Utah)

51-D Mission Facts (Cont)

Mission Duration: 144 hours (6 days), 23 hours, 55 minutes, 23 seconds
Miles Traveled: 2,889,785 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 109
Orbital Altitude: 248 by 160 nautical miles (nmi) (285 by 184 statute miles [sm]), then to 249 by 161 nmi (286 by 185 sm), then to 249 by 167 nmi (286 by 192 sm), then to 250 by 174 nmi (287 by 200 sm), then to 250 by 167 nmi (287 by 192 sm)
Landing Touchdown: Approximately 1,639 feet beyond runway threshold
Landing Rollout: Approximately 10,430 feet from main gear touchdown
Orbiter Weight at Landing: Approximately 198,014 pounds
Lift-off Weight: Approximately 4,505,245 pounds
Orbiter Weight at Lift-off: Approximately 250,891 pounds
Landing Speed at Main Gear Touchdown: Approximately 200 knots (230 miles per hour)
Cargo Weight Up: Approximately 35,824 pounds
Cargo Weight Down: Approximately 13,248 pounds
Landed: Runway 33 at Kennedy Space Center, Florida
Extravehicular activity (EVA): Jeffrey Hoffman and David Griggs, duration, 3 hours, 10 minutes
Payloads: Telesat (Canada communications satellite)-I with Payload Assist Module (PAM)-D deployment, Syncom IV-3 communications satellite deployment with its unique stage (unique stage failed to ignite), Continuous Flow Electrophoresis (CFES), Phase Partitioning Experiment (PPE), student experiments, two getaway specials (GAS)
Informal science studies (Toys in Space)

51-B Mission Facts — Challenger — April 29–May 6, 1985

Commander: Robert F. Overmyer
Pilot: Frederick D. Gregory
Mission Specialist: Don Leslie Lind
Mission Specialist: Norman E. Thagard
Mission Specialist: William E. Thornton
Payload Specialist: Taylor E. Wang
Payload Specialist: Lodewijk van den Berg
Mission Duration: 168 hours (7 days), 8 minutes, 46 seconds
Miles Traveled: Approximately 2,890,383 statute miles
Inclination: 57 degrees

51-B Mission Facts (Cont)

Orbits of Earth: 110
Orbital Altitude: 193 nautical miles (222 statute miles)
Landing Touchdown: Approximately 1,576 feet beyond runway threshold
Landing Rollout: Approximately 8,317 feet
Orbiter Weight at Landing: Approximately 212,465 pounds
Lift-off Weight: Approximately 4,512,009 pounds
Landing Speed at Main Gear Touchdown: Approximately 204 knots (234 miles per hour)
Cargo Weight Up: Approximately 31,407 pounds
Cargo Weight Down: Approximately 31,302 pounds
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
Payloads: Spacelab-3 experiments, habitable Spacelab and mission peculiar experiment support structure. The experiments represented a total of five different disciplines: materials processing in space, environmental observations, life science, astrophysics, and technology experiments. Two getaway specials (GAS).
The flight crew was split into gold and silver shifts working 12-hour days during the flight.

51-G Mission Facts — Discovery — June 17–24, 1985

Commander: Daniel Brandenstein
Pilot: John Creighton
Mission Specialist: John Fabian
Mission Specialist: Steven Nagel
Mission Specialist: Shannon Lucid
Payload Specialist: Patrick Baudry
Payload Specialist: Sultan Salman Abdul Azziz Al Sa'ud
Mission Duration: 168 hours (7 days), 1 hour, 38 minutes, 52 seconds
Miles Traveled: Approximately 2,916,127 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 111
Orbital Altitude: 190 by 191 nautical miles (nmi) (218 by 219 statute miles [sm]), then 191 by 197 nmi (219 by 226 sm), then 191 by 203 nmi (219 by 233 sm), then to 191 by 209 nmi (219 by 240 sm), then to 191 by 207 nmi (219 by 238 sm), then to 189 by 207 nmi (217 by 238 sm), then to 163 by 191 nmi (187 by 219 sm)
Landing Touchdown: Approximately 1,117 feet beyond threshold
Landing Rollout: Approximately 7,433 feet
Orbiter Weight at Lift-off: Approximately 256,421 pounds

51-G Mission Facts (Cont)

Orbiter Weight at Landing: Approximately 204,169 pounds

Lift-off Weight: Approximately 4,516,613 pounds

Cargo Weight Up: Approximately 44,477 pounds

Cargo Weight Down: Approximately 21,645 pounds

Landing Speed at Main Gear Touchdown: Approximately 198 knots (227 miles per hour)

Landed: Runway 23 dry lake bed at Edwards Air Force Base, California

Payloads: Deployment of Morelos (Mexico communications satellite)-A with Payload Assist Module (PAM)-D, Arabsat (Arab League communications satellite)-1B with PAM-D, and Telstar (American Telephone and Telegraph communications satellite) with PAM-D; Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN)-1; Automated Directional Solidification Furnace (ADSF); High Precision Tracking Experiment (HPTE); Orbiter Experiments (OEX); French Echocardiograph Experiment (FEE) and French Pocket Experiment (FPE)

51-F Mission Facts — Challenger — July 29–August 6, 1985

Commander: Gordon Fullerton

Pilot: Roy Bridges

Mission Specialist: Story Musgrave

Mission Specialist: Anthony England

Mission Specialist: Karl Henize

Payload Specialist: Loren Acton

Payload Specialist: John-David Bartoe

Mission Duration: 168 hours (7 days), 22 hours, 45 minutes, 26 seconds

Miles Traveled: Approximately 3,283,543 statute miles

Inclination: 49.5 degrees

Orbits of Earth: 126

Orbital Altitude: 143 by 108 nautical miles (nmi) (164 by 124 statute miles [sm]), 169 by 170 nmi (194 by 195 sm), 168 by 170 nmi (193 by 195 sm), 170 by 172 nmi (195 by 197 sm), 170 by 171 nmi (195 by 196 sm), 166 by 173 nmi (191 by 199 sm), 167 by 171 nmi (192 by 196 sm), 165 by 174 nmi (189 by 200 sm)

Landing Touchdown: Approximately 3,713 feet beyond threshold

Landing Rollout: Approximately 8,569 feet

Orbiter Weight at Lift-off: Approximately 252,628 pounds

Orbiter Weight at Landing: Approximately 216,735 pounds

Lift-off Weight: Approximately 4,515,554 pounds

51-F Mission Facts (Cont)

Cargo Weight Up and Down: Approximately 34,400 pounds

Landing Speed at Main Gear Touchdown: Approximately 199 knots (229 miles per hour)

Landed: Runway 23 dry lake bed at Edwards Air Force Base, California

Payloads: Spacelab-2 with 13 experiments, Shuttle Amateur Radio Experiment (SAREX), Protein Crystal Growth (PCG). The flight crew was divided into a red and blue team. Each team worked 12-hour shifts for 24-hour-a-day operation.

At 5 minutes, 45 seconds into ascent the number one engine shut down prematurely and an abort to orbit was declared.

51-I Mission Facts — Discovery — August 27–September 3, 1985

Commander: Joe H. Engle

Pilot: Richard O. Covey

Mission Specialist: James van Hoften

Mission Specialist: William F. Fisher

Mission Specialist: John M. Lounge

Mission Duration: 168 hours (7 days), 2 hours, 17 minutes, 42 seconds

Miles Traveled: 2,919,576 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 111

Orbital Altitude: 190 by 190 nautical miles (nmi) (218 by 218 statute miles [sm]), 196 by 191 nmi (225 by 219 sm), 202 by 190 nmi (232 by 218 sm), 202 by 191 nmi (232 by 219 sm), 212 by 170 nmi (243 by 195 sm), 239 by 169 nmi (275 by 194 sm), 242 by 169 nmi (278 by 194 sm), 242 by 178 nmi (278 by 204 sm)

Landing Touchdown: Approximately 2,101 feet beyond threshold

Landing Rollout: Approximately 6,100 feet

Orbiter Weight at Landing: Approximately 196,674 pounds

Landing Speed at Main Gear Touchdown: Approximately 191 knots (219 miles per hour)

Lift-off Weight: Approximately 4,512,130 pounds

Orbiter Weight at Lift-off: Approximately 262,309 pounds

Landed: Runway 23 dry lake bed at Edwards Air Force Base, California

Extravehicular Activity (EVA): James van Hoften and William Fisher. EVA 1 duration approximately 7 hours, 20 minutes, EVA 2 duration approximately 4 hours, 31 minutes

Cargo Weight Up: Approximately 43,988 pounds

51-I Mission Facts (Cont)

Cargo Weight Down: Approximately 13,452 pounds

Payloads: Deploy ASC (American Satellite Company)-1 with Payload Assist Modue (PAM)-D.
Deploy AUSSAT (Australian communications satellite)-1 with PAM-D. Deploy Syncom IV-4 communications satellite with its unique stage. Retrieve Leasat-3 communications satellite, repair and deploy by extravehicular activity (EVA) astronauts. Physical Vapor Transport Organic Solids (PVTOS) experiment

51-J Mission Facts — Atlantis — October 3–7, 1985

Commander: Karol J. Bobko

Pilot: Ronald J. Grabe

Mission Specialist: David C. Hilmers

Mission Specialist: Robert L. Stewart

Payload Specialist: Major William A. Pailes

Mission Duration: 96 hours (4 days), 1 hour, 44 minutes, 38 seconds

Inclination: 28.5 degrees

Orbital Altitude: 278 nautical miles (319 statute miles)*

Orbits of Earth: 63

Landing Touchdown: Approximately 2,476 feet beyond threshold

Landing Rollout: Approximately 8,056 feet

Landed: Runway 23 dry lake bed at Edwards Air Force Base, California

Payload: DOD

*Record altitude (as of 5/93)

61-A Mission Facts — Challenger — October 30–November 6, 1985

Commander: Henry W. Hartsfield, Jr.

Pilot: Steven R. Nagel

Mission Specialist: James F. Buchli

Mission Specialist: Guion S. Bluford, Jr.

Mission Specialist: Bonnie J. Dunbar

Payload Specialist: Reinhard Furrer, West Germany

Payload Specialist: Wubbo Ockels, Netherlands

Payload Specialist: Ernst Messerschmid, West Germany

Mission Duration: 168 hours (7 days), 44 minutes, 51 seconds

Miles Traveled: Approximately 2,909,352 statute miles

Inclination: 57 degrees

Orbits of Earth: 111

61-A Mission Facts (Cont)

Orbital Altitude: 180 nautical miles (207 statute miles) circular

Landing Touchdown: Approximately 1,829 feet beyond threshold

Landing Rollout: Approximately 8,304 feet

Orbiter Weight at Landing: Approximately 214,171 pounds

Lift-off Weight: Approximately 4,508,496 pounds

Payload Weight Up: Approximately 31,861 pounds

Payload Weight Down: Approximately 31,711 pounds

Landing Speed at Main Gear Touchdown: Approximately 203 knots (233 miles per hour)

Orbiter Weight at Lift-off: Approximately 243,762 pounds

Landed: Runway 17 dry lake bed at Edwards Air Force Base, California

Payload: Spacelab D-1 with habitable module and 76 experiments. Six of the eight crew members were divided into a blue and red team working 12-hour shifts for 24-hour-a-day operation. The remaining two crew members were "switch hitters."

61-B Mission Facts — Atlantis — November 26–December 3, 1985

Commander: Brewster A. Shaw

Pilot: Bryan D. O'Conner

Mission Specialist: Sherwood C. Spring

Mission Specialist: Mary L. Cleave

Mission Specialist: Jerry L. Ross

Payload Specialist: Charles D. Walker (McDonnell Douglas)

Payload Specialist: Rodolfo Neri Vela (Mexico)

Mission Duration: 144 hours (6 days), 21 hours, 4 minutes, 49 seconds

Miles Traveled: Approximately 2,838,972 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 108

Orbital Altitude: 190 by 190 nautical miles (218 by 218 statute miles), 190 by 195 nautical miles (218 by 224 statute miles), 196 by 195 nautical miles (225 by 224 statute miles), 196 by 204 nautical miles (225 by 234 statute miles)

Landing Touchdown: Approximately 2,386 feet beyond threshold

Landing Rollout: Approximately 10,759 feet

Orbiter Weight at Landing: Approximately 205,732 pounds

Lift-off Weight: Approximately 4,514,530 pounds

Payload Weight Up: Approximately 48,041 pounds

Payload Weight Down: Approximately 20,464 pounds

61-B Mission Facts (Cont)

Landing Speed at Touchdown: Approximately 189 knots (217 miles per hour)

Orbiter Weight at Lift-off: Approximately 261,610 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Extravehicular Activity (EVA): Jerry Ross and Sherwood Spring, EVA No. 1, duration 5 hours, 34 minutes. EVA No. 2, duration 6 hours, 46 minutes

Payloads: Deploy SATCOM (RCA-Satellite Communications) Ku-2 with Payload Assist Module (PAM)-D II. Deploy Morelos (Mexico communications satellite)-B with PAM-D. Deploy AUSSAT (Australian communications satellite)-2 with PAM-D. EASE/ACCESS (Assembly of Structures—Assembly Concept for Construction of Erectable Space Structures) by extravehicular activity (EVA) astronauts, Continuous Flow Electrophoresis System (CFES), Diffusive Mixing of Organic Solutions (DMOS), IMAX camera, one getaway special (GAS), Linhof camera and Hasseblad camera

61-C Mission Facts — Columbia — January 12–18, 1986

Commander: Robert L. Gibson

Pilot: Charles F. Bolden, Jr.

Mission Specialist: George D. Nelson

Mission Specialist: Steven A. Hawley

Mission Specialist: Franklin R. Chang-Diaz

Payload Specialist: Robert J. Cenker

Payload Specialist: Rep. Bill Nelson

Mission Duration: 144 hours (6 days), 2 hours, 3 minutes, 51 seconds

Miles Traveled: Approximately 2,528,658 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 97

Orbital Altitude: 185 nautical miles (212 statute miles) circular orbit

Landing Touchdown: Approximately 1,525 feet beyond threshold

Landing Rollout: Approximately 10,202 feet

Orbiter Weight at Landing: Approximately 210,161 pounds

Lift-off Weight: Approximately 4,509,360 pounds

Payload Weight Up: Approximately 32,462 pounds

Payload Weight Down: Approximately 20,111 pounds

Landing Speed at Touchdown: Approximately 217 knots (249 miles per hour)

61-C Mission Facts (Cont)

Orbiter Weight at Lift-off: Approximately 256,003 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Deploy SATCOM (RCA-Satellite Communications) Ku-1 with Payload Assist Module (PAM)-D II. Materials Science Laboratory, Comet Halley Active Monitoring Experiment (CHAMP), Hitchhiker (HH)—Goddard (G)-1, thirteen getaway specials (GAS), student experiment, Initial Blood Storage Equipment (IBSE), Characterization of Space Motion Sickness (SMS)

51-L Mission Facts — Challenger — January 28, 1986

Commander: Francis R. Scobee
Pilot: Michael J. Smith
Mission Specialist: Ellison S. Onizuka
Mission Specialist: Judith A. Resnik
Mission Specialist: Ronald E. McNair
Payload Specialist: Gregory Jarvis (Hughes)
Payload Specialist: Sharon Christa McAuliffe, Teacher In Space
Inclination: 28.45 degrees
Lift-off Weight: Approximately 4,526,583 pounds
Total Payload Weight Up: Approximately 52,308 pounds
Orbiter Weight at Lift-off: Approximately 268,829 pounds
Payloads: Tracking Data Relay Satellite (TDRS)-B, SPARTAN-203 Halley's Comet Experiment, Teacher in Space Project, Fluid Dynamics Experiment, Comet Halley Active Monitoring Program, Phase Partitioning Experiment (PPE), Radiation Monitoring Experiment (RME), three Shuttle Student Involvement Program experiments
Loss of vehicle and crew

STS-26 Mission Facts — Discovery — September 29–October 3, 1988

Commander: Frederick H. Hauck
Pilot: Richard O. Covey
Mission Specialist: John M. Lounge
Mission Specialist: George D. Nelson
Mission Specialist: David C. Hilmers

STS-26 Mission Facts (Cont)

Mission Duration: 96 hours (4 days), 1 hour, 11 seconds
Miles Traveled: Approximately 1.68 million statute miles
Inclination: 28.5 degrees
Orbits of Earth: 63
Orbital Altitude: 163 by 159 nautical miles (187 by 182 statute miles), 177 by 162 nautical miles (203 by 186 statute miles)
Landing Touchdown: Approximately 2,500 feet beyond threshold
Landing Rollout: Approximately 7,451 feet
Orbiter Weight at Landing: Approximately 194,184 pounds
Lift-off Weight: Approximately 4,522,411 pounds
Payload Weight Up: Approximately 46,478 pounds
Payload Weight Down: Approximately 8,964 pounds
Landing Speed at Touchdown: Approximately 187 knots (215 miles per hour)
Orbiter Weight at Lift-off: Approximately 254,606 pounds
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
Payloads: Deploy IUS (Inertial Upper Stage) with Tracking and Data Relay Satellite (TDRS)-C. 3M's Physical Vapor Transport Organics Solids 2 experiment (PVTOS), Automated Directional Solidification Furnace (ADSF), Infrared Communications Flight Experiment (IRCFE), Protein Crystal Growth II (PCG), Isoelectric Focusing (ISF)-2, Phase Partitioning Experiment (PPE), Aggregation of Red Blood Cells (ARC)-2, Mesoscale Lightning Experiment (MLE)-1, Earth Limb Radiance (ELRAD), Orbiter Experiments (OEX), Autonomous Supporting Instrumentation System (OASIS)-I, two Shuttle Student Involvement Project (SSIP) experiments

STS-27 Mission Facts — Atlantis — December 2–6, 1988

Commander: Robert L. Gibson
Pilot: Guy S. Gardner
Mission Specialist: Richard M. Mullane
Mission Specialist: Jerry L. Ross
Mission Specialist: William M. Shepherd
Mission Duration: 96 hours (4 days), 9 hours, 5 minutes, 35 seconds
Orbits of Earth: 68
Inclination: 57 degrees
Landing Speed at Touchdown: 194 knots (223 miles per hour)

STS-27 Mission Facts (Cont)

Landing Touchdown: Approximately 1,469 feet beyond threshold
Landing Rollout: Approximately 7,123 feet
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
Payload: DOD

STS-29 Mission Facts — Discovery — March 13–18, 1989

Commander: Michael L. Coats
Pilot: John E. Blaha
Mission Specialist: James F. Buchli
Mission Specialist: Robert C. Springer
Mission Specialist: James P. Bagian
Mission Duration: 96 hours (4 days), 23 hours, 38 minutes, 52 seconds
Miles Traveled: Approximately 2 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 79
Orbital Altitude: 160 nautical miles (184 statute miles), 160 by 177 nautical miles (184 by 203 statute miles)
Landing Touchdown: Approximately 1,195 feet beyond threshold
Landing Rollout: Approximately 9,339 feet
Orbiter Weight at Landing: Approximately 194,789 pounds
Lift-off Weight: Approximately 4,524,261 pounds
Payload Weight Up: Approximately 38,097 pounds
Payload Weight Down: Approximately 9,861 pounds
Landing Speed at Touchdown: Approximately 205 knots (235 miles per hour)
Orbiter Weight at Lift-off: Approximately 256,357 pounds
Landed: Concrete runway 22 at Edwards AFB, California
Payloads: Deploy IUS (Inertial Upper Stage) with Tracking and Data Relay Satellite (TDRS)-D. Protein Crystal Growth (PCG); Chromosome and Plant Cell Division in Space; IMAX 70mm camera; Shuttle Student Involvement Project (SSIP) experiments: SSIP 82-8, Effects of Weightlessness in Space Flight on the Healing of Bone Fractures, and SSIP 83-9, Chicken Embryo Development in Space; Air Force Maui Optical Site (AMOS) experiment.

STS-30 Mission Facts — Atlantis — May 4–8, 1989

Commander: David M. Walker
Pilot: Ronald J. Grabe
Mission Specialist: Norman E. Thagard
Mission Specialist: Mary L. Cleave
Mission Specialist: Mark C. Lee
Mission Duration: 96 hours (4 days), 57 minutes, 31 seconds
Miles Traveled: 1,681,997 statute miles
Inclination: 28.85 degrees
Orbits of Earth: 64
Orbital Altitude: 4 by 85 nautical miles (4.6 by 97 statute miles), 51 by 161 nautical miles (58 by 185 statute miles), 160 by 161 nautical miles (184 by 185 statute miles), 160 by 177 nautical miles (184 by 203 statute miles)
Landing Touchdown: Approximately 1,382 feet beyond threshold
Landing Rollout: Approximately 10,295 feet
Orbiter Weight at Landing: Approximately 192,459 pounds
Lift-off Weight: Approximately 4,527,426 pounds
Payload Weight Up: Approximately 45,930 pounds
Payload Weight Down: Approximately 7,701 pounds
Orbiter Weight at Lift-off: Approximately 261,118 pounds
Landing Speed at Touchdown: Approximately 196 knots (225 miles per hour)
Landed: Concrete runway 22 at Edwards AFB, California
Payloads: Deploy IUS with Magellan spacecraft. Fluids Experiment Apparatus (FEA). Mesoscale Lightning Experiment (MLE), Air Force Maui Optical Site (AMOS) experiment

STS-28 Mission Facts — Columbia — August 8–13, 1989

Commander: Brewster H. Shaw
Pilot: Richard N. Richards
Mission Specialist: David C. Leestma
Mission Specialist: James C. Adamson
Mission Specialist: Mark N. Brown
Mission Duration: 120 hours (5 days), 1 hour, 9 seconds
Inclination: 57 degrees
Landing Speed at Touchdown: Approximately 155 knots (178 miles per hour)
Landing Touchdown: Approximately 5,311 feet beyond threshold
Landing Rollout: Approximately 6,015 feet
Landed: Runway 17 dry lake bed at Edwards Air Force Base, California
Payload: DOD

STS-34 Mission Facts — Atlantis — October 18–23, 1989

Commander: Donald E. Williams
Pilot: Michael J. McCulley
Mission Specialist: Shannon W. Lucid
Mission Specialist: Ellen S. Baker
Mission Specialist: Franklin R. Chang-Diaz
Mission Duration: 96 hours (4 days), 23 hours, 39 minutes, 24 seconds
Miles Traveled: 2 million statute miles
Inclination: 34.30 degrees; first flight at this inclination
Orbits of Earth: 79
Orbital Altitude: 156 by 39 nautical miles (179 by 44 statute miles), 160 by 161 nautical miles (184 by 185 statute miles), 161 by 179 nautical miles (185 by 205 statute miles)
Landing Rollout: Approximately 9,677 feet
Orbiter Weight at Landing: Approximately 195,954 pounds
Lift-off Weight: Approximately 4,524,224 pounds
Payload Weight Up: Approximately 48,643 pounds
Payload Weight Down: Approximately 10,625 pounds
Orbiter Weight at Lift-off: Approximately 257,569 pounds
Landing Speed at Touchdown: Approximately 195 knots (224 miles per hour)
Landed: Runway 23 dry lake bed at Edwards Air Force Base, California
Payloads: Deploy IUS with Galileo spacecraft. Shuttle Solar Backscatter Ultraviolet (SSBUV), Polymer Morphology (PM) experiments, IMAX camera project, Mesoscale Lightning Experiment (MLE), Air Force Maui Optical Site (AMOS) experiment, Growth Hormone Concentration and Distribution (GHCD) in Plants experiment, Sensor Technology Experiment (STEX), SSIP Student Experiment (SE) 82-15, Ice Crystals Experiment

STS-33 Mission Facts — Discovery — November 22–27, 1989

Commander: Frederick D. Gregory
Pilot: John E. Blaha
Mission Specialist: F. Story Musgrave
Mission Specialist: Kathryn C. Thornton
Mission Specialist: Manley L. Carter, Jr.
Mission Duration: 120 hours (5 days), 6 minutes, 49 seconds
Miles Traveled: 2 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 78
Landing Speed at Touchdown: Approximately 199 knots (229 miles per hour)

STS-33 Mission Facts (Cont)

Landing Touchdown: Approximately 1,871 feet beyond threshold

Landing Rollout: Approximately 7,764 feet

Landed: Concrete runway 04 at Edwards Air Force Base, California

Payload: DOD

This was the third Space Shuttle night launch.

STS-32 Mission Facts — Columbia — January 9–20, 1990

Commander: Daniel C. Brandenstein

Pilot: James D. Wetherbee

Mission Specialist: Bonnie J. Dunbar

Mission Specialist: G. David Low

Mission Specialist: Marsha S. Ivins

Mission Duration: 240 hours (10 days), 21 hours, 37 seconds

Miles Traveled: 4,509,972 statute miles

Inclination: 28.5 degrees

Orbits of Earth: 171

Orbital Altitude: (Approximation due to rendezvous sequence in real time) 193 by 155 nautical miles (222 by 178 statute miles), 194 by 156 nautical miles (233 by 179 statute miles), 183 by 169 nautical miles (210 by 194 statute miles), 184 by 177 nautical miles (211 by 203 statute miles), 181 by 176 nautical miles (208 by 202 statute miles), 181 by 175 nautical miles (208 by 201 statute miles)

Landing Rollout: Approximately 10,731 feet

Landing Touchdown: 1,870 feet beyond threshold

Orbiter Weight at Landing: Approximately 228,335 pounds

Lift-off Weight: Approximately 4,519,487 pounds

Payload Weight Up: Approximately 26,488 pounds

Payload Weight Down: Approximately 21,393 pounds

Orbiter Weight at Lift-off: Approximately 255,994 pounds

Landing Speed at Touchdown: Approximately 207 knots (238 miles per hour)

Landed: Concrete runway 22 at Edwards Air Force Base, California (night landing)

Payloads: Deployment of Syncom IV-5, retrieval of Long Duration Exposure Facility (LDEF), Fluids Experiment Apparatus (FEA)-3, Protein Crystal Growth (PCG) III-2, Latitude/Longitude Locator (L3), American Flight Echocardiograph (AFE), Characterization of Neurospora Circadian Rhythms in Space (CNCR)-01, Air Force Maui Optical Site (AMOS)-4, Mesoscale Lightning Experiment (MLE), IMAX, Interim Operational Contamination Monitor (IOCM)

STS-36 Mission Facts — Atlantis — February 28–March 4, 1990

Commander: John O. Creighton
Pilot: John H. Casper
Mission Specialist: David C. Hilmers
Mission Specialist: Richard M. Mullane
Mission Specialist: Pierre J. Thuot
Mission Duration: 96 hours (4 days), 10 hours, 18 minutes, 23 seconds
Inclination: 62 degrees*
Landing Speed at Touchdown: Approximately 199 knots (229 miles per hour)
Landing Touchdown: Approximately 1,622 feet beyond threshold
Landing Rollout: 7,900 feet
Landed: Runway 23 dry lake bed at Edwards Air Force Base, California
Payload: DOD
*Record high (through 5/93)

STS-31 Mission Facts — Discovery — April 24–29, 1990

Commander: Loren J. Shriver
Pilot: Charles F. Bolden
Mission Specialist: Steven A. Hawley
Mission Specialist: Bruce McCandless II
Mission Specialist: Kathryn D. Sullivan
Mission Duration: 120 hours (5 days), 1 hour, 16 minutes, 5 seconds
Miles Traveled: 2,068,213 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 76
Orbital Altitude: 311 by 331 nautical miles (357 by 380 statute miles), 331 by 332 nautical miles (380 by 382 statute miles), 330 by 334 nautical miles (379 by 384 statute miles)
Landing Touchdown: Approximately 1,291 feet beyond threshold
Landing Rollout: Approximately 8,874 feet
Orbiter Weight at Landing: Approximately 189,118 pounds
Lift-off Weight: Approximately 4,514,665 pounds
Orbiter Weight at Lift-off: Approximately 249,109 pounds
Landing Speed at Main Gear Touchdown: Approximately 177 knots (203 miles per hour)
Payload Weight Up: Approximately 28,673 pounds
Payload Weight Down: Approximately 4,768 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California

STS-31 Mission Facts (Cont)

Payloads: Deployment of Hubble Space Telescope, IMAX camera in payload bay and in crew compartment, Protein Crystal Growth III-03, Investigation Into Polymer Membrane Processing-01, Air Force Maui Optical Site-05, Radiation Monitoring Equipment III-01, Student Experiment 82-16, and Ascent Particle Monitor 01

STS-41 Mission Facts — Discovery — October 6–10, 1990

Commander: Richard N. Richards
Pilot: Robert D. Cabana
Mission Specialist: Bruce E. Melnick
Mission Specialist: William M. Shepherd
Mission Specialist: Thomas D. Akers
Mission Duration: 96 hours (4 days), 2 hours, 10 minutes
Miles Traveled: 1,707,445 statute miles
Inclination: 28.5 degrees
Orbits of Earth: 65
Orbital Altitude: 160 by 160 nautical miles (184 by 184 statute miles), 177 by 160 nautical miles (203 by 184 statute miles), 160 by 156 nautical miles (184 by 179 statute miles), 157 by 156 nautical miles (180 by 179 statute miles)
Landing Touchdown: Approximately 2,295 feet beyond threshold
Landing Rollout: Approximately 8,532 feet
Orbiter Weight at Landing: Approximately 197,986 pounds
Lift-off Weight: Approximately 4,523,894 pounds
Orbiter Weight at Lift-off: Approximately 293,019 pounds
Landing Speed at Main Gear Touchdown: Approximately 194 knots (223 miles per hour)
Payload Weight Up: Approximately 48,812 pounds
Payload Weight Down: Approximately 10,279 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Deploy Ulysses, Shuttle Solar Backscatter Ultraviolet, Intelsat Solar Array Coupon, Solid-Surface Combustion Experiment, Investigations Into Polymer Membrane Processing, Chromosome and Plant Cell Division in Space, Physiological Systems Experiment, Voice Command System, Radiation Monitoring Equipment III, Air Force Maui Optical Site

STS-38 Mission Facts — Atlantis — November 15–20, 1990

Commander: Richard O. Covey
Pilot: Frank L. Culbertson
Mission Specialist: Robert C. Springer
Mission Specialist: Carl J. Meade
Mission Specialist: Charles D. "Sam" Gemar
Mission Duration: 96 hours (4 days), 21 hours, 55 minutes, 22 seconds
Orbits of Earth: 79
Inclination: 28.5 degrees
Landing Speed at Touchdown: Approximately 194 knots (223 miles per hour)
Landing Touchdown: Approximately 1,414 feet beyond threshold
Landing Rollout: Approximately 8,900 feet
Landed: Runway 33 at Kennedy Space Center, Florida
Payload: DOD

STS-35 Mission Facts — Columbia — December 2–10, 1990

Commander: Vance D. Brand
Pilot: Guy S. Gardner
Mission Specialist: Jeffrey A. Hoffman
Mission Specialist: John M. Lounge
Mission Specialist: Robert A.R. Parker
Payload Specialist: Samuel T. Durrance
Payload Specialist: Ronald A. Parise
Mission Duration: 192 hours (8 days), 23 hours, 5 minutes, 8 seconds
Miles Traveled: 3,728,636 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 142
Orbital Altitude: 190 by 190 nautical miles (218 by 218 statute miles)
Landing Touchdown: Approximately 2,000 feet beyond threshold
Landing Rollout: Approximately 10,837 feet
Orbiter Weight at Landing: Approximately 225,886 pounds
Lift-off Weight: Approximately 4,523,199 pounds
Orbiter Weight at Lift-off: Approximately 267,392 pounds
Landing Speed at Main Gear Touchdown: Approximately 202 knots (232 miles per hour)
Payload Weight Up: Approximately 26,330 pounds
Payload Weight Down: Approximately 26,330 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Ultraviolet Astronomy Telescope (Astro), Broad-Band X-Ray Telescope (BBXRT), Shuttle Amateur Radio Experiment (SAREX), Air Force Maui Optical Site (AMOS).

STS-37 Mission Facts — Atlantis — April 5–11, 1991

Commander: Steven R. Nagel
Pilot: Kenneth D. Cameron
Mission Specialist: Jerry L. Ross
Mission Specialist: Jerome Apt
Mission Specialist: Linda M. Godwin
Mission Duration: 120 hours (5 days), 23 hours, 32 minutes, 44 seconds
Miles Traveled: 2,456,263 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 93
Orbital Altitude: 243 nautical miles (280 statute miles) circular orbit
Landing Touchdown: Approximately 632 feet before threshold
Landing Rollout: Approximately 6,600 feet
Orbiter Weight at Landing: Approximately 191,050 pounds
Lift-off Weight: Approximately 4,519,158 pounds
Orbiter Weight at Lift-off: Approximately 254,971 pounds
Landing Speed at Main Gear Touchdown: Approximately 188 knots (216 miles per hour)
Payload Weight Up: Approximately 36,621 pounds
Payload Weight Down: Approximately 2,279 pounds
Landed: Runway 33 dry lake bed at Edwards Air Force Base, California
Payloads: Gamma-Ray Observatory (GRO), Crew/Equipment Translation Aids (part of Extravehicular Activity Development Flight Experiment), Ascent Particle Monitor (APM), Bioserve Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA), Protein Crystal Growth (PCG)-Block II, Space Station Heatpipe Advanced Radiator Element (SHARE)-II, Shuttle Amateur Radio Experiment (SAREX)-II, Radiation Monitoring Equipment (RME)-III, Air Force Maui Optical Site (AMOS) Calibration Test
Extravehicular Activity (EVA): Jerry L. Ross and Jerome Apt: EVA No. 1 duration, 4 hours, 38 minutes; EVA No. 2 duration, 6 hours, 11 minutes. EVA No. 1 was an unscheduled EVA to manually deploy the Gamma-Ray Observatory's high-gain antenna, which failed to deploy upon ground command. Following the successful deploy of the antenna, the astronauts spent the remainder of the EVA on Extravehicular Activity Development Flight Experiment activities.

STS-39 Mission Facts — Discovery — April 28–May 6, 1991

Commander: Michael L. Coats
Pilot: L. Blaine Hammond, Jr.
Mission Specialist: Gregory J. Harbaugh
Mission Specialist: Donald R. McMonagle
Mission Specialist: Guion S. Bluford, Jr.
Mission Specialist: Charles L. (Lacy) Veach
Mission Specialist: Richard J. Hieb
Mission Duration: 192 hours (8 days), 7 hours, 22 minutes, 22 seconds
Miles Traveled: Approximately 3.47 million statute miles
Inclination: 57 degrees
Orbits of Earth: 134
Orbital Altitude: 140 nautical miles (161 statute miles) circular orbit
Landing Touchdown: Approximately 168 feet beyond threshold
Landing Rollout: Approximately 9,152 feet
Orbiter Weight at Landing: Approximately 210,811 pounds
Lift-off Weight: Approximately 4,512,698 pounds
Orbiter Weight at Lift-off: Approximately 246,986 pounds
Landing Speed at Main Gear Touchdown: Approximately 210 knots (242 miles per hour)
Payload Weight Up: Approximately 21,413 pounds
Payload Weight Down: Approximately 20,586 pounds
Landed: Runway 15 at Kennedy Space Center, Florida
Payloads: Infrared Background Signature Survey (IBSS), Air Force Program (AFP)-675, Space Test Payload (STP)-I, Multi-Purpose Experiment Canister (MPEC), Cloud Logic to Optimize Use of Defense Systems (CLOUDS)-1A, Radiation Monitoring Equipment (RME)-III

STS-40 Mission Facts — Columbia — June 5–14, 1991

Commander: Bryan D. O'Conner
Pilot: Sidney M. Gutierrez
Mission Specialist: M. Rhea Seddon
Mission Specialist: James P. Bagian
Mission Specialist: Tamara E. Jernigan
Payload Specialist: F. Drew Gaffney
Payload Specialist: Millie Hughes-Fulford
Mission Duration: 216 hours (9 days), 2 hours, 14 minutes, 20 seconds
Miles Traveled: Approximately 3,779,940 statute miles
Inclination: 39 degrees

STS-40 Mission Facts (Cont)

Orbits of Earth: 146
Orbital Altitude: 160 by 150 nautical miles (184 by 172 statute miles)
Landing Touchdown: Approximately 1,485 feet beyond threshold
Landing Rollout: Approximately 9,438 feet
Orbiter Weight at Landing: Approximately 226,534 pounds
Lift-off Weight: Approximately 4,519,081 pounds
Orbiter Weight at Lift-off: Approximately 250,398 pounds
Landing Speed at Main Gear Touchdown: Approximately 200 knots (230 miles per hour)
Payload Weight Up: Approximately 25,942 pounds
Payload Weight Down: Approximately 25,942 pounds
Landed: Concrete runway 22 at Edwards AFB, California
Payloads: Spacelab Life Sciences (SLS)-1 with long module, getaway special bridge assembly with 12 getaway specials, Physiological Monitoring System (PMS), Urine Monitoring System (UMS), Animal Enclosure Modules (AEM), Middeck Zero-gravity Dynamics Experiment (MODE), 7 Orbiter Experiments Program experiments

STS-43 Mission Facts — Atlantis — August 2–11, 1991

Commander: John E. Blaha
Pilot: Michael A. Baker
Mission Specialist: Shannon W. Lucid
Mission Specialist: G. David Low
Mission Specialist: James C. Adamson
Mission Duration: 192 hours (8 days), 21 hours, 21 minutes, 25 seconds
Miles Traveled: Approximately 3,700,400 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 142
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit
Landing Touchdown: Approximately 1,986 feet beyond threshold
Landing Rollout: Approximately 9,890 feet
Orbiter Weight at Landing: Approximately 196,735 pounds
Lift-off Weight: Approximately 4,526,488 pounds
Orbiter Weight at Lift-off: Approximately 259,382 pounds
Landing Speed at Main Gear Touchdown: Approximately 203 knots (233 miles per hour)
Payload Weight Up: Approximately 46,882 pounds
Payload Weight Down: Approximately 9,242 pounds

STS-43 Mission Facts (Cont)

Landed: Runway 15 at Kennedy Space Center, Florida

Payloads: Tracking and Data Relay Satellite (TDRS)-E/Inertial Upper Stage (IUS), Space Station Heatpipe Advanced Radiator Element (SHARE)-II, Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument 03, Optical Communications Through the Shuttle Window (OCTW), Air Force Maui Optical Site (AMOS) Calibration Test, Auroral Photography Experiment (APE)-B, Bioserve-Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA)-02, Investigations Into Polymer Membrane Processing (IPMP)-03, Protein Crystal Growth III Block II, Space Acceleration Measurement System (SAMS), Solid Surface Combustion Experiment (SSCE)-02, Tank Pressure Control Experiment (TPCE)

STS-48 Mission Facts — Discovery — September 12–18, 1991

Commander: John O. Creighton

Pilot: Kenneth S. Reightler, Jr.

Mission Specialist: James F. Buchli

Mission Specialist: Mark N. Brown

Mission Specialist: Charles D. "Sam" Gemar

Mission Duration: 120 hours (5 days), 8 hours, 27 minutes, 34 seconds

Miles Traveled: Approximately 2,193,670 statute miles

Inclination: 57 degrees

Orbits of Earth: 81

Orbital Altitude: 308 nautical miles (355 statute miles) circular orbit

Landing Touchdown: Approximately 1,829 feet beyond threshold

Landing Rollout: Approximately 8,790 feet

Orbiter Weight at Landing: Approximately 192,507 pounds

Lift-off Weight: Approximately 4,507,348 pounds

Orbiter Weight at Lift-off: Approximately 239,735 pounds

Landing Speed at Main Gear Touchdown: Approximately 216 knots (249 miles per hour)

Payload Weight Up: Approximately 17,317 pounds

Payload Weight Down: Approximately 2,898 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Payloads: Upper Atmosphere Research Satellite (UARS), Ascent Particle Monitor (APM)-03, Physiological and Anatomical Rodent Experiment (PARE)-01, Protein Crystal Growth (PCG)-II-2, Middeck Zero-Gravity Dynamics

Experiment (MODE)-01, Investigations Into Polymer Membrane Processing (IPMP)-04, Cosmic Radiation Effects and Activation Monitor (CREAM-02), Radiation Monitoring Equipment (RME)-III-06, Shuttle Activation Monitor (SAM)-03, Air Force Maui Optical Site (AMOS) Calibration Test

STS-44 Mission Facts — Atlantis — November 24–December 1, 1991

Commander: Frederick D. Gregory
Pilot: Terrence T. Henricks
Mission Specialist: F. Story Musgrave
Mission Specialist: Mario Runco, Jr.
Mission Specialist: James S. Voss
Payload Specialist: Thomas J. Hennen
Mission Duration: 144 hours (6 days), 22 hours, 50 minutes, 42 seconds
Miles Traveled: Approximately 2,890,067 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 109
Orbital Altitude: 195 nautical miles (225 statute miles) circular orbit
Landing Touchdown: Approximately 2,607 feet beyond threshold
Landing Rollout: Approximately 11,191 feet
Orbiter Weight at Landing: Approximately 193,825 pounds
Lift-off Weight: Approximately 4,526,272 pounds
Orbiter Weight at Lift-off: Approximately 259,629 pounds
Landing Speed at Main Gear Touchdown: Approximately 183 knots (210 miles per hour)
Payload Weight Up: Approximately 44,628 pounds
Payload Weight Down: Approximately 7,010 pounds
Landed: Runway 05 dry lake bed at Edwards Air Force Base, California
Payloads: Defense Support Program satellite/ Inertial Upper Stage, Interim Operational Contamination Monitor, Terra Scout, Military Man in Space, Shuttle Activation Monitor, Cosmic Radiation Effects and Activation Monitor, Radiation Monitoring Equipment III, Air Force Maui Optical Site Calibration Test, Ultraviolet Plume Instrument, Visual Function Tester 1

STS-42 Mission Facts — Discovery — January 22–30, 1992

Commander: Ronald J. Grabe
Pilot: Stephen S. Oswald
Mission Specialist: David C. Hilmers

STS-42 Mission Facts (Cont)

Mission Specialist: Norman E. Thagard
Mission Specialist: William F. Readdy
Payload Specialist: Ulf D. Merbold
Payload Specialist: Roberta L. Bondar
Mission Duration: 192 hours (8 days), 1 hour, 14 minutes, 45 seconds
Miles Traveled: Approximately 3,359,830 statute miles
Inclination: 57 degrees
Orbits of Earth: 129
Orbital Altitude: 163 nautical miles (188 statute miles) circular orbit
Landing Touchdown: Approximately 2,835 feet beyond threshold
Landing Rollout: Approximately 9,811 feet
Orbiter Weight at Landing: Approximately 218,016 pounds
Lift-off Weight: Approximately 4,507,474 pounds
Orbiter Weight at Lift-off: Approximately 243,395 pounds
Landing Speed at Main Gear Touchdown: Approximately 199 knots (229 miles per hour)
Payload Weight Up: Approximately 28,663 pounds
Payload Weight Down: Approximately 28,663 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: International Microgravity Laboratory (IML)-1, getaway special (GAS) bridge with 10 getaway specials, IMAX camera, Gelation of Sols: Applied Microgravity Research (GOSAMR)-1, Investigations Into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME)-III, Student Experiment 81-09: Convection in Zero Gravity, Student Experiment 83-02: Capillary Rise of Liquid Through Granular Porous Media

STS-45 Mission Facts — Atlantis — March 24–April 2, 1992

Commander: Charles F. Bolden
Pilot: Brian Duffy
Payload Commander: Kathryn D. Sullivan
Mission Specialist: David C. Leestma
Mission Specialist: C. Michael Foale
Payload Specialist: Dirk D. Frimout
Payload Specialist: Byron K. Lichtenberg
Mission Duration: 192 hours (8 days), 22 hours, 9 minutes, 25 seconds
Miles Traveled: Approximately 3,724,946 statute miles

STS-45 Mission Facts (Cont)

Inclination: 57 degrees
Orbits of Earth: 143
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit
Landing Touchdown: Approximately 1,800 feet beyond threshold
Landing Rollout: Approximately 9,217 feet
Orbiter Weight at Landing: Approximately 205,042 pounds
Lift-off Weight: Approximately 4,496,035 pounds
Orbiter Weight at Lift-off: Approximately 233,650 pounds
Landing Speed at Main Gear Touchdown: Approximately 195 knots (224 miles per hour)
Payload Weight Up: Approximately 17,683 pounds
Payload Weight Down: Approximately 17,683 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Atmospheric Laboratory for Applications and Science (ATLAS)-1, Shuttle Solar Backscatter Ultraviolet (SSBUV)-4, Getaway Special Experiment G-229, Space Tissue Loss (STL)-1, Radiation Monitoring Equipment (RME)-III, Visual Function Tester (VFT)-II, Cloud Logic To Optimize Use of Defense Systems (CLOUDS)-1A, Investigations Into Polymer Membrane Processing (IPMP), Shuttle Amateur Radio Experiment (SAREX)-II, Ultraviolet Plume Instrument (UVPI)

STS-49 Mission Facts — Endeavour — May 7–16, 1992

Commander: Daniel C. Brandenstein
Pilot: Kevin P. Chilton
Mission Specialist: Pierre J. Thuot
Mission Specialist: Kathryn C. Thornton
Mission Specialist: Richard J. Hieb
Mission Specialist: Thomas D. Akers
Mission Specialist: Bruce E. Melnick
Mission Duration: 192 hours (8 days), 21 hours, 17 minutes, 39 seconds
Miles Traveled: Approximately 3,696,019 statute miles
Inclination: 28.35 degrees
Orbits of Earth: 141
Orbital Altitude: 183 by 95 nautical miles (211 by 109 statute miles) minimum orbit
Landing Touchdown: Approximately 2,166 feet beyond threshold
Landing Rollout: Approximately 9,490 feet
Orbiter Weight at Landing: Approximately 201,649 pounds

STS-49 Mission Facts (Cont)

Lift-off Weight: Approximately 4,519,238 pounds
Orbiter Weight at Lift-off: Approximately 256,597 pounds
Landing Speed at Main Gear Touchdown: Approximately 198 knots (228 miles per hour)
Payload Weight Up: Approximately 32,598 pounds
Payload Weight Down: Approximately 8,558 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Intelsat-VI reboost mission hardware, Assembly of Station by EVA Methods (ASEM), Commercial Protein Crystal Growth (CPCG), Air Force Maui Optical Site (AMOS) Calibration Test, Ultraviolet Plume Instrument (UVPI)
Extravehicular Activity (EVA): EVA No. 1, Pierre J. Thuot and Richard J. Hieb, 3 hours, 43 minutes duration; EVA No. 2, Pierre J. Thuot and Richard J. Hieb, 5 hours, 30 minutes duration; EVA No. 3, Pierre J. Thuot, Richard J. Hieb, and Thomas D. Akers, 8 hours, 29 minutes duration (first three-person EVA and longest U.S. spacewalk to date); and EVA No. 4, Kathryn C. Thornton and Thomas D. Akers, 7 hours, 45 minutes duration (most EVAs on a flight to date). During EVAs 1 and 2, Thuot and Hieb attempted unsuccessfully to retrieve the Intelsat-VI satellite using a capture bar. On EVA 3, Thuot, Hieb, and Akers manually captured the satellite, which was subsequently repaired and redeployed. EVA 4 was used to evaluate Space Station assembly by EVA methods.
First active dual rendezvous of two orbiting spacecraft (Endeavour and Intelsat-VI)
First deployment of a drag chute on the orbiter fleet

STS-50 Mission Facts — Columbia — June 25–July 9, 1992

Commander: Richard N. Richards
Pilot: Kenneth D. Bowersox
Payload Commander: Bonnie J. Dunbar
Mission Specialist: Ellen S. Baker
Mission Specialist: Carl J. Meade
Payload Specialist: Lawrence J. DeLucas
Payload Specialist: Eugene H. Trinh
Mission Duration: 312 hours (13 days), 19 hours, 30 minutes, 4 seconds
Miles Traveled: Approximately 5,758,000 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 221
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit

STS-50 Mission Facts (Cont)

Landing Touchdown: Approximately 2,352 feet beyond threshold
Landing Rollout: Approximately 10,674 feet
Orbiter Weight at Landing: Approximately 228,127 pounds
Lift-off Weight: Approximately 4,519,680 pounds
Orbiter Weight at Lift-off: Approximately 257,265 pounds
Landing Speed at Main Gear Touchdown: Approximately 209 knots (241 miles per hour)
Payload Weight Up: Approximately 24,589 pounds
Payload Weight Down: Approximately 24,589 pounds
Landed: Runway 33 at Kennedy Space Center, Florida
Payloads: United States Microgravity Laboratory (USML)-1; Orbital Acceleration Research Experiment (OARE); Investigations Into Polymer Membrane Processing (IPMP), Shuttle Amateur Radio Experiment (SAREX)-II; Ultraviolet Plume Instrument (UVPI)
First extended-duration mission

STS-46 Mission Facts — Atlantis — July 31–August 8, 1992

Commander: Loren J. Shriver
Pilot: Andrew M. Allen
Payload Commander: Jeffrey A. Hoffman
Mission Specialist: Franklin R. Chang-Diaz
Mission Specialist: Claude Nicollier
Mission Specialist: Marsha S. Ivins
Payload Specialist: Dr. Franco Malerbo
Mission Duration: 168 hours (7 days), 23 hours, 16 minutes, 7 seconds
Miles Traveled: Approximately 3,321,007 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 127
Orbital Altitude: 127 nautical miles (146 statute miles) circular orbit
Landing Touchdown: Approximately 1,950 feet beyond threshold
Landing Rollout: Approximately 10,860 feet
Orbiter Weight at Landing: Approximately 208,806 pounds
Lift-off Weight: Approximately 4,516,789 pounds
Orbiter Weight at Lift-off: Approximately 256,031 pounds
Landing Speed at Main Gear Touchdown: Approximately 204 knots (234 miles per hour)
Payload Weight Up: Approximately 28,585 pounds
Payload Weight Down: Approximately 18,594 pounds

STS-46 Mission Facts (Cont)

Landed: Runway 33 at Kennedy Space Center, Florida

Payloads: Tethered Satellite System (TSS)-1; European Retrievable Carrier (EURECA)-1L; Evaluation of Oxygen Integration with Materials (EOIM)-III/ Thermal Energy Management Processes (TEMP)-2A; Consortium for Materials Development In Space Complex Autonomous Payloads (CONCAP)-II and III; IMAX Cargo Bay Camera (ICBC); Limited Duration Space Environment Candidate Materials Exposure (LDCE); Pituitary Growth Hormone Cell Function (PHCF); Ultraviolet Plume Instrument (UVPI)

STS-47 Mission Facts — Endeavour — September 12–20, 1992

Commander: Robert L. Gibson

Pilot: Curtis L. Brown, Jr.

Mission Specialist: Mark C. Lee

Mission Specialist: Jerome Apt

Mission Specialist: N. Jan Davis

Mission Specialist: Dr. Mae C. Jemison

Payload Specialist: Mamoru Mohri

Mission Duration: 168 hours (7 days), 22 hours, 31 minutes, 11 seconds

Miles Traveled: Approximately 3,310,922 statute miles

Inclination: 57 degrees

Orbits of Earth: 127

Orbital Altitude: 163 nautical miles (188 statute miles) circular orbit

Landing Touchdown: Approximately 2,458 feet beyond threshold

Landing Rollout: Approximately 8,567 feet

Orbiter Weight at Landing: Approximately 219,327 pounds

Lift-off Weight: Approximately 4,506,649 pounds

Orbiter Weight at Lift-off: Approximately 244,413 pounds

Landing Speed at Main Gear Touchdown: Approximately 211 knots (243 miles per hour)

Payload Weight Up: Approximately 28,158 pounds

Payload Weight Down: Approximately 28,158 pounds

Landed: Runway 33 at Kennedy Space Center, Florida

Payloads: Spacelab-J, nine getaway special canister experiments, Israel Space Agency Investigation About Hornets (ISAIAH), Shuttle Amateur Radio Experiment (SAREX) II, Solid Surface Combustion Experiment (SSCE)

STS-52 Mission Facts — Columbia — October 22–November 1, 1992

Commander: James D. Wetherbee
Pilot: Michael A. Baker
Mission Specialist: William M. Shepherd
Mission Specialist: Tamara E. Jernigan
Mission Specialist: Charles Lacy Veach
Payload Specialist: Steven MacLean
Mission Duration: 216 hours (9 days), 20 hours, 56 minutes, 13 seconds
Miles Traveled: Approximately 4,129,028 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 159
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit, then 155 nautical miles (178 statute miles) circular orbit, then 113 nautical miles (130 statute miles) circular orbit
Landing Touchdown: Approximately 1,080 feet beyond threshold
Landing Rollout: Approximately 10,708 feet
Orbiter Weight at Landing: Approximately 215,114 pounds
Lift-off Weight: Approximately 4,514,325 pounds
Orbiter Weight at Lift-off: Approximately 250,130 pounds
Landing Speed at Main Gear Touchdown: Approximately 211 knots (243 miles per hour)
Payload Weight Up: Approximately 20,077 pounds
Payload Weight Down: Approximately 14,419 pounds
Landed: Runway 33 at Kennedy Space Center, Florida
Payloads: Laser Geodynamic Satellite (LAGEOS) II/Italian Research Interim Stage (IRIS), Canadian Experiments (CANEX) 2, United States Microgravity Payload (USMP) 1, Attitude Sensor Package (ASP), Tank Pressure Control Experiment (TPCE), Physiological Systems Experiment (PSE), Heat Pipe Performance (HPP) experiment, Commercial Protein Crystal Growth (CPCG), Shuttle Plume Impingement Experiment (SPIE), Commercial Materials ITA Experiment (CMIX), Crystals by Vapor Transport Experiment (CVTE)

STS-53 Mission Facts — Discovery — December 2–9, 1992

Commander: David M. Walker
Pilot: Robert D. Cabana
Mission Specialist: Guion S. Bluford
Mission Specialist: James S. Voss
Mission Specialist: Michael Richard "Rich" V. Clifford
Mission Duration: 168 hours (7 days), 7 hours, 19 minutes, 17 seconds

STS-53 Mission Facts (Cont)

Miles Traveled: Approximately 3,034,680 statute miles
Inclination: 57 degrees
Orbits of Earth: 116
Orbital Altitude: 200 nautical miles (230 statute miles) circular orbit (DOD-1 deployment), then 175 nautical miles (202 statute miles) circular orbit (ODERACS deployment)
Landing Touchdown: Approximately 1,190 feet beyond threshold
Landing Rollout: Approximately 10,165 feet
Orbiter Weight at Landing: Approximately 193,215 pounds
Lift-off Weight: Approximately 4,506,642 pounds
Orbiter Weight at Lift-off: Approximately 243,952 pounds
Landing Speed at Main Gear Touchdown: Approximately 209 knots (241 miles per hour)
Payload Weight Up: Approximately 26,166 pounds
Payload Weight Down: Approximately 5,151 pounds
Landed: Concrete Runway 22 at Edwards Air Force Base, California
Payloads: Department of Defense (DOD)1; Glow Experiment/Cryogenic Heat Pipe Experiment Payload (GCP); Orbital Debris Radar Calibration System (ODERACS); Battlefield Laser Acquisition Sensor Test (BLAST); Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A; Cosmic Radiation Effects and Activation Monitor (CREAM); Fluid Acquisition and Resupply Equipment (FARE); Hand-held, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting and Environmental System (HERCULES); Microencapsulation in Space (MIS)-1; Radiation Monitoring Equipment (RME) III; Spare Tissue Loss (STL); Visual Function Tester (VFT)2. The ODERACS payload was unable to be deployed because of payload equipment malfunction.

STS-54 Mission Facts — Endeavour — January 13–19, 1993

Commander: John H. Casper
Pilot: Donald R. McMonagle
Mission Specialist 1: Mario Runco, Jr.
Mission Specialist 2: Gregory J. Harbaugh
Mission Specialist 3: Susan J. Helms
Mission Duration: 120 hours (5 days), 23 hours, 38 minutes, 17 seconds
Miles Traveled: Approximately 2,501,277 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 96

STS-54 Mission Facts (Cont)

Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit
Landing Touchdown: Approximately 1,500 feet beyond threshold
Landing Rollout: Approximately 8,700 feet
Orbiter Weight at Landing: Approximately 197,778 pounds
Lift-off Weight: Approximately 4,522,692 pounds
Orbiter Weight at Lift-off: Approximately 259,264 pounds
Landing Speed at Main Gear Touchdown: Approximately 205 knots (236 miles per hour)
Payload Weight Up: Approximately 46,643 pounds
Payload Weight Down: Approximately 9,068 pounds
Landed: Concrete Runway 33 at Kennedy Space Center, Florida
Extravehicular Activity (EVA): Gregory J. Harbaugh and Mario Runco, Jr. Duration 4 hours, 27 minutes, 50 seconds
Payloads: Tracking and Data Relay Satellite (TDRS)-F/Inertial Upper Stage (IUS); Diffuse X-ray Spectrometer (DXS); Chromosome and Plant Cell Division in Space (CHROMEX); Commercial Generic Bioprocessing Apparatus (CGBA) A; Physiological and Anatomical Rodent Experiment (PARE) 02; Solid Surface Combustion Experiment (SSCE)

STS-56 Mission Facts — Discovery — April 8–17, 1993

Commander: Kenneth Cameron
Pilot: Stephen S. Oswald
Mission Specialist 1: Michael Foale
Mission Specialist 2: Kenneth D. Cockrell
Mission Specialist 3: Ellen Ochoa
Mission Duration: 216 hours (9 days) 6 hours, 8 minutes, 23 seconds
Miles Traveled: Approximately 3,853,997 statute miles
Inclination: 57 degrees
Orbits of Earth: 148
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit
Landing Touchdown: Approximately 1,075 feet beyond threshold
Landing Rollout: Approximately 9,529 feet
Orbiter Weight at Landing: Approximately 206,855 pounds
Lift-off Weight: Approximately 4,500,815 pounds
Orbiter Weight at Lift-off: Approximately 236,659 pounds

STS-56 Mission Facts (Cont)

Landing Speed at Main Gear Touchdown: Approximately 196 knots (226 miles per hour)
Payload Weight Up: Approximately 16,406 pounds
Payload Weight Down: Approximately 16,406 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Atmospheric Laboratory for Applications and Science (ATLAS) 2, Shuttle Solar Backscatter Ultraviolet (SSBUV) A, Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201 (Solar Wind Generation Experiment), Solar Ultraviolet Experiment (SUVE), Commercial Material Dispersion Apparatus (CMIX), Physiological and Anatomical Rodent Experiment (PARE), Handheld, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting, and Environmental System (HERCULES), Shuttle Amateur Radio Experiment (SAREX) II, Space Tissue Loss (STL), Air Force Maui Optical Site (AMOS), Cosmic Radiation Effects and Activation Monitor (CREAM), Radiation Monitoring Equipment (RME) III

STS-55 Mission Facts — Columbia — April 26–May 6, 1993

Commander: Steven R. Nagel
Pilot: Terrence T. Henricks
Payload Commander: Jerry L. Ross
Mission Specialist 2: Charles J. Precourt
Mission Specialist 3: Bernard A. Harris, Jr.
Payload Specialist 1: Ulrich Walter, Germany
Payload Specialist 2: Hans Schlegel, Germany
Mission Duration: 216 hours (9 days) 23 hours, 39 minutes, 59 seconds
Miles Traveled: Approximately 4,164,183 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 160
Orbital Altitude: 160 nautical miles (184 statute miles) circular orbit
Landing Touchdown: Approximately 1,819 feet beyond threshold
Landing Rollout: Approximately 10,125 feet
Orbiter Weight at Landing: Approximately 227,203 pounds
Lift-off Weight: Approximately 4,518,784 pounds
Orbiter Weight at Lift-off: Approximately 255,252 pounds
Landing Speed at Main Gear Touchdown: Approximately 210 knots (242 miles per hour)
Payload Weight Up: Approximately 26,864 pounds

STS-55 Mission Facts (Cont)

Payload Weight Down: Approximately 26,864 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Payloads: Spacelab D-2 with long module, unique support structure (USS), and Reaction Kinetics in Glass Melts (RKGM) getaway special, Shuttle Amateur Radio Experiment (SAREX) II

STS-57 Mission Facts — Endeavour — June 21–July 1, 1993

Commander: Ronald J. Grabe

Pilot: Brian J. Duffy

Payload Commander: G. David Low

Mission Specialist 2: Nancy J. Sherlock

Mission Specialist 3: Peter J.K. "Jeff" Wisoff

Mission Specialist 4: Janice E. Voss

Mission Duration: 216 hours (9 days), 23 hours, 44 minutes, 54 seconds

Miles Traveled: Approximately 4,118,037 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 155

Orbital Altitude: 250 nautical miles (287 statute miles) circular orbit

Landing Touchdown: Approximately 2,305 feet beyond threshold

Landing Rollout: Approximately 9,946 feet

Orbiter Weight at Landing: Approximately 244,400 pounds

Lift-off Weight: Approximately 4,516,459 pounds

Orbiter Weight at Lift-off: Approximately 252,359 pounds

Landing Speed at Main Gear Touchdown: Approximately 200 knots (230 miles per hour)

Payload Weight Up: Approximately 19,691 pounds

Payload Weight Down: Approximately 28,925 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Spacehab 01, retrieval of European Retrievable Carrier (EURECA) Satellite, Superfluid Helium On-Orbit Transfer (SHOOT), Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP)-IV, Fluid Acquisition and Resupply Experiment (FARE), Shuttle Amateur Radio Experiment (SAREX) II, Air Force Maui Optical Site (AMOS), GAS bridge assembly with 12 getaway special payloads

Extravehicular Activity (EVA): G. David Low and Peter J.K. "Jeff" Wisoff, 5 hours, 50 minutes duration. During the EVA, Low and Wisoff conducted tests to refine procedures being developed to service the Hubble Space Telescope and to prepare for construction of the Space Station.

STS-51 Mission Facts — Discovery — September 12–22, 1993

Commander: Frank L. Culbertson, Jr.

Pilot: William F. Readdy

Mission Specialist 1: James H. Newman

Mission Specialist 2: Daniel W. Bursch

Mission Specialist 3: Carl E. Walz

Mission Duration: 216 hours (9 days), 20 hours, 11 minutes, 11 seconds

Miles Traveled: Approximately 4,106,411 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 158

Orbital Altitude: 160 nautical miles (185 statute miles) circular orbit

Landing Touchdown: Approximately 2,099 feet beyond threshold

Landing Rollout: Approximately 8,271 feet

Orbiter Weight at Landing: Approximately 206,438 pounds

Lift-off Weight: Approximately 4,525,870 pounds

Orbiter Weight at Lift-off: Approximately 261,597 pounds

Landing Speed at Main Gear Touchdown: Approximately 198 knots (228 miles per hour)

Payload Weight Up: Approximately 42,682 pounds

Payload Weight Down: Approximately 8,567 pounds

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: Advanced Communication Technology Satellite (ACTS)/Transfer Orbit Stage (TOS), Orbiting Retrievable Far and Extreme Ultraviolet Spectrometer—Shuttle Pallet Satellite (ORFEUS-SPAS) with Remote IMAX Camera System (RICS), Limited Duration Space Environment Candidate Materials Exposure (LDCE) (Beam Configuration C), Commercial Protein Crystal Growth (CPCG—Block II), Chromosome and Plant Cell Division in Space (CHROMEX), High Resolution Shuttle Glow Spectroscopy-A (HRSGS-A), Auroral Photography Experiment-B (APE-B), Investigation into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME-III), Air Force Maui Optical Site Calibration Test (AMOS), IMAX In-Cabin Camera

Extravehicular Activity (EVA): Carl E. Walz and James H. Newman, 7 hours, 5 minutes duration. During the EVA, Walz and Newman conducted tests in support of the Hubble Space Telescope first servicing mission and future EVAs, including Space Station assembly and maintenance.

STS-58 Mission Facts — Columbia — October 18–November 1, 1993

Commander: John E. Blaha
Pilot: Richard A. Searfoss
Payload Commander: M. Rhea Seddon
Mission Specialist: Shannon W. Lucid
Mission Specialist: David A. Wolf
Mission Specialist: William S. McArthur, Jr.
Payload Specialist: Dr. Martin J. Fettman
Mission Duration: 336 hours (14 days), 0 hours, 12 minutes, 32 seconds
Miles Traveled: Approximately 5,840,450 statute miles
Inclination: 39 degrees
Orbits of Earth: 225
Orbital Altitude: 153 nautical miles (176 statute miles) circular orbit
Landing Touchdown: Approximately 3,380 feet beyond threshold
Landing Rollout: Approximately 9,640 feet
Orbiter Weight at Landing: Approximately 229,753 pounds
Lift-off Weight: Approximately 4,519,968 pounds
Orbiter Weight at Lift-off: Approximately 256,007 pounds
Landing Speed at Main Gear Touchdown: Approximately 205 knots (236 miles per hour)
Payload Weight Up: Approximately 23,188 pounds
Payload Weight Down: Approximately 23,188 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Spacelab Life Sciences (SLS) 2, Shuttle Amateur Radio Experiment (SAREX) II

STS-61 Mission Facts — Endeavour — December 2–13, 1993

Commander: Richard O. Covey
Pilot: Kenneth Bowersox
Payload Commander: F. Story Musgrave
Mission Specialist: Thomas D. Akers
Mission Specialist: Jeffrey A. Hoffman
Mission Specialist: Kathryn C. Thornton
Mission Specialist: Claude Nicollier, European Space Agency
Mission Duration: 240 hours (10 days), 19 hours, 58 minutes, 33 seconds
Miles Traveled: Approximately 4,433,772 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 163
Orbital Altitude: 311 nautical miles (358 statute miles)
Landing Touchdown: Approximately 2,903 feet beyond threshold

Landing Rollout: Approximately 7,922 feet

Orbiter Weight at Landing: Approximately 211,210 pounds

Lift-off Weight: Approximately 4,515,150 pounds

Orbiter Weight at Lift-off: Approximately 250,314 pounds

Landing Speed at Main Gear Touchdown: Approximately 192 knots (221 miles per hour)

Payload Weight Up: Approximately 17,662 pounds

Payload Weight Down: Approximately 17,662 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Hubble Space Telescope (HST) Servicing Mission (SM) 1, IMAX Camera, IMAX Cargo Bay Camera (ICBC), Air Force Maui Optical Site (AMOS)

Extravehicular Activity (EVA): EVA No. 1, F. Story Musgrave and Jeffrey A. Hoffman, 7 hours, 54 minutes duration; EVA No. 2, Thomas D. Akers and Kathryn C. Thornton, 6 hours, 36 minutes duration; EVA No. 3, F. Story Musgrave and Jeffrey A. Hoffman, 6 hours, 47 minutes duration; EVA No. 4, Thomas D. Akers and Kathryn C. Thornton, 6 hours, 50 minutes duration; EVA No. 5, F. Story Musgrave and Jeffrey A. Hoffman, 7 hours, 21 minutes duration. During EVA 1, Musgrave and Hoffman successfully changed out Hubble's rate sensing units and electronics control unit and eight fuse plugs. The spacewalk was the second longest in NASA history. During EVA 2, Akers and Thornton installed two new solar arrays and jettisoned one of Hubble's original solar arrays, which was bent. During EVA 3, Musgrave and Hoffman removed and stored the telescope's original wide-field/planetary camera and installed the replacement Wide-Field/Planetary Camera II and two new magnetometers. During EVA 4, Akers and Thornton removed the telescope's high-speed photometer and installed the corrective optics space telescope axial replacement unit and a new computer coprocessor. Akers broke the all-time American spacewalking record previously set by Eugene Cernan, accumulating a total of 29 hours and 40 minutes. During EVA 5, Musgrave and Hoffman replaced the telescope's solar array drive electronics and installed the Goddard high-resolution spectrograph redundancy kit and two Mylar covers over the original magnetometers to contain any contamination or debris that might come off the instrument and protect it from ultraviolet degradation.

Most EVAs on a Space Shuttle Flight: 5

STS-60 Mission Facts — Discovery — February 3–11, 1994

Commander: Charles F. Bolden, Jr.
Pilot: Kenneth S. Reightler, Jr.
Mission Specialist: Franklin R. Chang-Diaz
Mission Specialist: N. Jan Davis
Mission Specialist: Ronald M. Sega
Mission Specialist: Sergei K. Krikalev, Russian cosmonaut
Mission Duration: 192 hours (8 days), 7 hours, 10 minutes, 13 seconds
Miles Traveled: Approximately 3,439,704 statute miles
Inclination: 57 degrees
Orbits of Earth: 131
Orbital Altitude: 190 nautical miles (219 statute miles)
Landing Speed at Main Gear Touchdown: Approximately 192 knots (221 miles per hour)
Orbiter Weight at Landing: Approximately 214,944 pounds
Lift-off Weight: Approximately 4,508,352 pounds
Orbiter Weight at Lift-off: Approximately 245,278 pounds
Landing Touchdown: Approximately 2,380 feet beyond threshold
Landing Rollout: Approximately 10,144 feet
Payload Weight Up: Approximately 28,674 pounds
Payload Weight Down: Approximately 28,499 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Wake Shield Facility (WSF) 1 and SPACEHAB 02. Getaway special bridge assembly experiments: Capillary Pumped Loop (CAPL), Orbital Debris Radar Calibration Spheres (ODERACS), University of Bremen Satellite (BREMSAT), G-514, G-071, and G-536. Shuttle Amateur Radio Experiment (SAREX) II; Auroral Photography Experiment (APE-B)

STS-62 Mission Facts — Columbia — March 4–18, 1994

Commander: John H. Casper
Pilot: Andrew M. Allen
Mission Specialist: Pierre J. Thuot
Mission Specialist: Charles D. "Sam" Gemar
Mission Specialist: Marsha S. Ivins
Mission Duration: 312 hours (13 days), 23 hours, 17 minutes, 28 seconds
Miles Traveled: Approximately 5,820,146 statute miles
Inclination: 39 degrees
Orbits of Earth: 224
Orbital Altitude: 160 nautical miles (184 statute miles)

STS-62 Mission Facts (Cont)

Landing Touchdown: Approximately 2,905 feet beyond threshold
Landing Rollout: Approximately 10,166 feet
Orbiter Weight at Landing: Approximately 226,742 pounds
Lift-off Weight: Approximately 4,519,308 pounds
Orbiter Weight at Lift-off: Approximately 256,086 pounds
Landing Speed at Main Gear Touchdown: Approximately 211 knots (242 miles per hour)
Payload Weight Up: Approximately 19,556 pounds
Payload Weight Down: Approximately 19,556 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: United States Microgravity Payload (USMP) 2, Office of Aeronautics and Space Technology (OAST) 2, Dexterous End Effector (DEE), Shuttle Solar Backscatter Ultraviolet/A (SSBUV/A), Limited-Duration Space Environment Candidate Material Exposure (LDCE), Advanced Protein Crystal Growth (APCG), Physiological Systems Experiment (PSE), Commercial Protein Crystal Growth (CPCG), Commercial Generic Bioprocessing Apparatus (CGBA), Auroral Photography Experiment Phase B (APE-B), Middeck Zero-Gravity Dynamics Experiment (MODE), Air Force Maui Optical Site (AMOS) Calibration Test, Bioreactor Demonstration System A.

STS-59 Mission Facts — Endeavour — April 9–20, 1994

Commander: Sidney M. Gutierrez
Pilot: Kevin P. Chilton
Payload Commander: Linda M. Godwin
Mission Specialist: Jay Apt
Mission Specialist: Michael R. "Rich" Clifford
Mission Specialist: Thomas D. Jones
Mission Duration: 264 hours (11 days), 5 hours, 49 minutes, 30 seconds
Miles Traveled: Approximately 4,704,835 statute miles
Inclination: 57 degrees
Orbits of Earth: 183
Orbital Altitude: 120 nautical miles (138 statute miles)
Landing Touchdown: Approximately 1,619 feet beyond threshold
Landing Rollout: Approximately 10,636 feet
Orbiter Weight at Landing: Approximately 221,713 pounds
Lift-off Weight: Approximately 4,510,987 pounds

STS-59 Mission Facts (Cont)

Orbiter Weight at Lift-off: Approximately 246,575 pounds

Landing Speed at Main Gear Touchdown: Approximately 228 knots (262 miles per hour)

Payload Weight Up: Approximately 27,536 pounds

Payload Weight Down: Approximately 27,536 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, California

Payloads: Space Radar Laboratory (SRL) 1; Consortium for Materials Development in Space Com-plex Autonomous Payload (CONCAP) IV; three getaway special (GAS) payloads; Space Tissue Loss (STL) A, B; Visual Function Tester (VFT) 4; Shuttle Amateur Radio Experiment (SAREX) II

STS-65 Mission Facts — Columbia — July 8–23, 1994

Commander: Robert D. Cabana

Pilot: James D. Halsell, Jr.

Payload Commander: Richard J. Hieb

Mission Specialist: Carl E. Walz

Mission Specialist: Leroy Chiao

Mission Specialist: Donald A. Thomas

Payload Specialist: Chiaki Mukai, Japan

Mission Duration: 336 hours (14 days), 17 hours, 56 minutes

Miles Traveled: Approximately 6,100,000 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 236

Orbital Altitude: 160 nautical miles (184 statute miles)

Landing Touchdown: Approximately 2,996 feet beyond threshold

Landing Rollout: Approximately 10,211 feet

Orbiter Weight at Landing: Approximately 229,522 pounds

Lift-off Weight: Approximately 4,522,475 pounds

Orbiter Weight at Lift-off: Approximately 258,333 pounds

Landing Speed at Main Gear Touchdown: Approximately 207 knots (238 miles per hour)

Payload Weight Up: Approximately 23,836 pounds

Payload Weight Down: Approximately 23,836 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: International Microgravity Laboratory (IML) 2, Orbital Acceleration Research Experiment (OARE), Commercial Protein Crystal Growth (CPCG), Air Force Maui Optical Site (AMOS), Military Applications of Ship Tracks (MAST), Shuttle Amateur Radio Experiment (SAREX)

STS-64 Mission Facts — Discovery — September 9–20, 1994

Commander: Richard N. Richards
Pilot: L. Blaine Hammond, Jr.
Mission Specialist: Carl J. Meade
Mission Specialist: Mark C.Lee
Mission Specialist: Susan J. Helms
Mission Specialist: Jerry M. Linenger
Mission Duration: 240 hours (10 days), 22 hours, 49 minutes, 57 seconds
Miles Traveled: Approximately 4,576,174 statute miles
Inclination: 57 degrees
Orbits of Earth: 177
Orbital Altitude: 140 nautical miles (161 statute miles)
Landing Touchdown: Approximately 3,386 feet beyond threshold
Landing Rollout: Approximately 9,656 feet
Orbiter Weight at Landing: Approximately 212,056 pounds
Lift-off Weight: Approximately 4,504,154 pounds
Orbiter Weight at Lift-off: Approximately 242,768 pounds
Landing Speed at Main Gear Touchdown: Approximately 207.8 knots (239 miles per hour)
Payload Weight Up: Approximately 20,417 pounds
Payload Weight Down: Approximately 20,375 pounds
Landed: Concrete runway 04 at Edwards Air Force Base, California
Payloads: Lidar In-Space Technology Experiment (LITE), Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201-II, Robot-Operated Materials Processing System (ROMPS), Shuttle Plume Impingement Flight Experiment (SPIFEX), getaway special (GAS) bridge assembly with ten GAS experiments, Trajectory Control Sensor (TCS), Simplified Aid for EVA Rescue (SAFER), Solid Surface Combustion Experiment (SSCE), Biological Research in Canisters (BRIC) III, Radiation Monitoring Experiment (RME) III, Military Applications of Ship Tracks (MAST), Shuttle Amateur Radio Experiment (SAREX) II, Air Force Maui Optical Site (AMOS) Calibration Test
Extravehicular Activity (EVA): Mark C. Lee and Carl J. Meade, for 6 hours, 51 minutes. Lee and Meade tested the Simplified Aid for EVA Rescue (SAFER), a small, self-contained propulsive backpack device that provides free-flying mobility for an EVA astronaut in an emergency. They also evaluated several tools and an electronic cuff checklist that allows crew members greater and easier access to information away from the spacecraft.

STS-68 Mission Facts — Endeavour — September 30–October 11, 1994

Commander: Michael A. Baker
Pilot: Terrence W. Wilcutt
Payload Commander: Thomas David Jones
Mission Specialist: Steven L. Smith
Mission Specialist: Peter J.K. "Jeff" Wisoff
Mission Specialist: Daniel W. Bursch
Mission Duration: 264 hours (11 days), 5 hours, 47 minutes, 8 seconds
Miles Traveled: Approximately 4,703,000 statute miles
Inclination: 57 degrees
Orbits of Earth: 183
Orbital Altitude: 120 nautical miles (138 statute miles) circular orbit
Landing Touchdown: Approximately 3,522 feet beyond threshold
Landing Rollout: Approximately 8,495 feet
Orbiter Weight at Landing: Approximately 222,026 pounds
Lift-off Weight: Approximately 4,510,392 pounds
Orbiter Weight at Lift-off: Approximately 247,129 pounds
Landing Speed at Main Gear Touchdown: Approximately 230 knots (265 miles per hour)
Payload Weight Up: Approximately 27,582 pounds
Payload Weight Down: Approximately 27,582 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Space Radar Laboratory (SRL) 2, five Getaway Special payloads, Chromosome and Plant Cell Division in Space (CHROMEX) 5, Biological Research in Canisters (BRIC) 01, Cosmic Radiation Effects and Activation Monitor (CREAM), Military Application of Ship Tracks (MAST), Commercial Protein Crystal Growth (CPCG)

STS-66 Mission Facts — Atlantis — November 3–14, 1994

Commander: Donald R. McMonagle
Pilot: Curtis L. Brown, Jr.
Payload Commander: Ellen Ochoa
Mission Specialist: Scott E. Parazynski
Mission Specialist: Joseph R. Tanner
Mission Specialist: Jean-Francois Clervoy, European Space Agency
Mission Duration: 240 hours (10 days), 22 hours, 34 minutes, 51 seconds
Miles Traveled: Approximately 4,554,791 statute miles
Inclination: 57 degrees

STS-66 Mission Facts (Cont)

Orbits of Earth: 174
Orbital Altitude: 164 nautical miles (189 statute miles)
Landing Touchdown: Approximately 3,219 feet beyond threshold
Landing Rollout: Approximately 7,647 feet
Orbiter Weight at Landing: Approximately 209,842 pounds
Lift-off Weight: Approximately 4,508,369 pounds
Orbiter Weight at Lift-off: Approximately 243,839 pounds
Landing Speed at Main Gear Touchdown: Approximately 196 knots (226 miles per hour)
Payload Weight Up: Approximately 23,247 pounds
Payload Weight Down: Approximately 23,247 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Atmospheric Laboratory for Applications and Science (ATLAS) 3, Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA)-Shuttle Pallet Satellite (SPAS) 1, Experiment of the Sun for Complementing the ATLAS Payload for Education (ESCAPE) II, Inter-Mars Tissue Equivalent Proportional Counter (ITEPC), Shuttle Solar Backscatter Ultraviolet (SSBUV) A, Physiological and Anatomical Rodent Experiment (PARE/NIH-R), Protein Crystal Growth (PCG-TES and PCG-STES), Space Tissue Loss (STL/NIH-C-A), Shuttle Acceleration Measurement System (SAMS), Heat Pipe Performance (HPP)

STS-63 Mission Facts — Discovery — February 3–11, 1995

Commander: James D. Wetherbee
Pilot: Eileen Marie Collins
Mission Specialist: C. Michael Foale
Mission Specialist: Janice E. Voss
Mission Specialist: Bernard A. Harris, Jr.
Mission Specialist: Vladimir Titov, Russian Space Agency
Mission Duration: 192 hours (8 days), 6 hours, 29 minutes, 35 seconds
Miles Traveled: Approximately 2,992,806 statute miles
Inclination: 51.6 degrees
Orbits of Earth: 130
Orbital Altitude: 170-213 nautical miles (196-245 statute miles)
Landing Touchdown: Approximately 1,261 feet beyond threshold

STS-63 Mission Facts (Cont)

Landing Rollout: Approximately 11,008 feet
Orbiter Weight at Landing: Approximately 211,278 pounds
Lift-off Weight: Approximately 4,511,481 pounds
Orbiter Weight at Lift-off: Approximately 247,476 pounds
Landing Speed at Main Gear Touchdown: Approximately 206 knots (237 miles per hour)
Payload Weight Up: Approximately 19,051 pounds
Payload Weight Down: Approximately 18,994 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Florida
Payloads: SPACEHAB 03, Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 204, Cryo Systems Experiment (CSE)/GLO-2 Experiment Payload (CGP)/Orbital Debris Radar Calibration Spheres (ODERACS) 2, Solid Surface Combustion Experiment (SSCE), Air Force Maui Optical Site (AMOS), IMAX Cargo Bay Camera (ICBC)
Note: Discovery rendezvoused with Russia's space station, Mir, to a distance of 37 feet and performed a fly-around.
Extravehicular Activity (EVA): Bernard A. Harris, Jr., and C. Michael Foale, for 4 hours, 39 minutes. Harris and Foale evaluated spacesuit modifications that would provide astronauts with better thermal protection from cold and practiced handling large objects in space in order to increase NASA's experience base as it prepares for the on-orbit assembly of the international space station. The EVA was terminated prematurely when Harris and Foale reported they were getting too cold.

STS-67 Mission Facts — Endeavour — March 2–18, 1995

Commander: Stephen S. Oswald
Pilot: William G. Gregory
Payload Commander: Tamara E. Jernigan
Mission Specialist: John M. Grunsfeld
Mission Specialist: Wendy B. Lawrence
Payload Specialist: Ronald A. Parise
Payload Specialist: Samuel T. Durrance
Mission Duration: 384 hours (16 days), 15 hours, 9 minutes, 46 seconds
Miles Traveled: Approximately 6,900,000 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 263
Orbital Altitude: 190 nautical miles (219 statute miles)

STS-67 Mission Facts (Cont)

Landing Touchdown: Approximately 1,672 feet beyond threshold
Landing Rollout: Approximately 9,975 feet
Orbiter Weight at Landing: Approximately 217,989 pounds
Lift-off Weight: Approximately 4,520,785 pounds
Orbiter Weight at Lift-off: Approximately 256,293 pounds
Landing Speed at Main Gear Touchdown: Approximately 201 knots (231 miles per hour)
Payload Weight Up: Approximately 28,916 pounds
Payload Weight Down: Approximately 28,916 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Ultraviolet Astronomy (ASTRO) 2; Middeck Active Control Experiment (MACE); Protein Crystal Growth—Thermal Enclosure System (PCG-TES) 03; Protein Crystal Growth—Single-Locker Thermal Enclosure System (PCG-STES) 02; Commercial Materials Dispersion Apparatus Minilab/Instrumentation Technology Associates, Inc. Experiments (CMIX) 03; Shuttle Amateur Radio Experiment (SAREX) II; two getaway special experiments

STS-71 Mission Facts — Atlantis — June 27–July 7, 1995

Commander: Robert L. "Hoot" Gibson
Pilot: Charles J. Precourt, Jr.
Mission Specialist: Ellen S. Baker
Mission Specialist: Gregory J. Harbaugh
Mission Specialist: Bonnie J. Dunbar
Mir-19 Crew Member: Anatoly Solovyez (Russia)—up only
Mir-19 Crew Member: Nikolai Budarin (Russia)—up only
Mir-18 Crew Member: Vladimir Dezhurov (Russia)—down only
Mir-18 Crew Member: Gennadiy Strekalov (Russia)—down only
Mir-18 Crew Member: Norman E. Thagard (U.S.)—down only
Mission Duration: 216 hours (9 days), 19 hours, 23 minutes, 8 seconds
Miles Traveled: Approximately 4,100,000 statute miles
Inclination: 51.6 degrees
Orbits of Earth: 154
Orbital Altitude: 213 nautical miles (245 statute miles)
Landing Touchdown: Approximately 2,324 feet beyond threshold

STS-71 Mission Facts (Cont)

Landing Rollout: Approximately 8,353 feet
Orbiter Weight at Landing: Approximately 214,709 pounds
Lift-off Weight: Approximately 4,511,483 pounds
Orbiter Weight at Lift-off: Approximately 248,417 pounds
Landing Speed at Main Gear Touchdown: Approximately 206 knots (237 miles per hour)
Payload Weight Up: Approximately 26,878 pounds
Payload Weight Down: Approximately 27,410 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Florida
Payloads: Shuttle/Mir Mission 1, Spacelab-Mir, IMAX camera, Shuttle Amateur Radio Experiment (SAREX)

STS-70 Mission Facts — Discovery — July 13–22, 1995

Commander: Terrence T. Henricks
Pilot: Kevin R. Kregel
Mission Specialist: Nancy J. Currie
Mission Specialist: Donald A. Thomas
Mission Specialist: Mary Ellen Weber
Mission Duration: 192 hours (8 days), 22 hours, 20 minutes, 5 seconds
Miles Traveled: Approximately 3,700,000 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 142
Orbital Altitude: 160 nautical miles (184 statute miles)
Landing Touchdown: Approximately 2,696 feet beyond threshold
Landing Rollout: Approximately 8,472 feet
Orbiter Weight at Landing: Approximately 194,911 pounds
Lift-off Weight: Approximately 4,521,772 pounds
Orbiter Weight at Lift-off: Approximately 258,584 pounds
Landing Speed at Main Gear Touchdown: Approximately 199 knots (229 miles per hour)
Payload Weight Up: Approximately 44,445 pounds
Payload Weight Down: Approximately 6,671 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida

STS-70 Mission Facts (Cont)

Payloads: Tracking and Data Relay Satellite (TDRS) G/Inertial Upper Stage (IUS); Bioreactor Demonstration System (BDS) B; Biological Research in Canisters (BRIC); Commercial Protein Crystal Growth (CPCG); Hand-Held, Earth-Oriented, Real-Time, Cooperative, User-Friendly, Location-Targeting and Environmental System (HERCULES); Microcapsules in Space (MIS) B; Physiological and Anatomical Rodent Experiment (PARE)/National Institutes of Health (NIH) Rodents (R); Radiation Monitoring Experiment (RME) III; Shuttle Amateur Radio Experiment (SAREX) II; Space Tissue Loss (STL)/National Institutes of Health (NIH) Cells (C); Military Applications of Ship Tracks (MAST); Visual Function Tester (VFT) 4; Window Experiment (WINDEX)

STS-69 Mission Facts — Endeavour — September 7–18, 1995

Commander: David M. Walker
Pilot: Kenneth D. Cockrell
Payload Commander: James S. Voss
Mission Specialist: James H. Newman
Mission Specialist: Michael L. Gernhardt
Mission Duration: 240 hours (10 days), 20 hours, 29 minutes, 52 seconds
Miles Traveled: Approximately 4,500,000 statute miles
Inclination: 28.45 degrees
Orbits of Earth: 171
Orbital Altitude: 200 nautical miles (230 statute miles)
Landing Touchdown: Approximately 1,912 feet beyond threshold
Landing Rollout: Approximately 10,230 feet
Orbiter Weight at Landing: Approximately 219,887 pounds
Lift-off Weight: Approximately 4,520,139 pounds
Orbiter Weight at Lift-off: Approximately 256,808 pounds
Landing Speed at Main Gear Touchdown: Approximately 218 knots (251 miles per hour)
Payload Weight Up: Approximately 25,352 pounds
Payload Weight Down: Approximately 25,304 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Wake Shield Facility (WSF) 2; Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201; International Extreme Ultraviolet Hitchhiker (IEH)1; Inter-Mars Tissue Equivalent Proportional Counter (ITEPC); Extravehicular Activity Development Flight Test (EDFT) 2; Capillary Pumped Loop (CAPL) 2/

STS-69 Mission Facts (Cont)

getaway special (GAS) bridge assembly with five GAS payloads; Auroral Photography Experiment (APE) B; Biological Research in Canisters (BRIC); Commercial Generic Bioprocessing Apparatus (CGBA), Configuration A; Electrolysis Performance Improvement Concept Study (EPICS); Space Tissue Loss (STL)/National Institutes of Health (NIH)—Cells (C); Commercial Middeck Instrumentation Technology Associates Experiment (CMIX)

Extravehicular Activity (EVA): James S. Voss and Michael L. Gernhardt for 6 hours, 45 minutes. Voss and Gernhardt performed a number of tasks designed to evaluate and verify specific assembly and maintenance techniques and tools for the International Space Station. They also evaluated spacesuit design modifications to protect spacewalkers from the extremely cold space environment as well as an electronic cuff checklist device worn on the wrist.

STS-73 Mission Facts — Columbia — October 20–November 5, 1995

Commander: Kenneth D. Bowersox

Pilot: Kent V. Rominger

Payload Commander: Kathryn C. Thornton

Mission Specialist: Catherine G. "Cady" Coleman

Mission Specialist: Michael E. Lopez-Alegria

Payload Specialist: Fred W. Leslie

Payload Specialist: Albert Sacco, Jr.

Mission Duration: 360 hours (15 days), 21 hours, 53 minutes, 16 seconds

Miles Traveled: Approximately 6.6 million statute miles

Inclination: 39 degrees

Orbits of Earth: 256

Orbital Altitude: 150 nautical miles (173 statute miles)

Landing Touchdown: Approximately 2,500 feet beyond threshold

Landing Rollout: Approximately 9,117 feet

Orbiter Weight at Landing: Approximately 230,164 pounds

Lift-off Weight: Approximately 4,521,539 pounds

Orbiter Weight at Lift-off: Approximately 257,162 pounds

Landing Speed at Main Gear Touchdown: Approximately 213 knots (245 miles per hour)

Payload Weight Up: Approximately 33,622 pounds

Payload Weight Down: Approximately 33,622 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: United States Microgravity Laboratory (USML) 2, Orbital Acceleration Research Experiment (OARE)

STS-74 Mission Facts — Atlantis — November 12–20, 1995

Commander: Kenneth D. Cameron

Pilot: James D. Halsell, Jr.

Mission Specialist 1: Chris A. Hadfield, Canadian Space Agency

Mission Specialist 2: Jerry L. Ross

Mission Specialist 3: William S. McArthur, Jr.

Mir 20 Crew Members (Aboard Mir):

Commander: Yuri Gidzenko, Russian Space Agency

Flight Engineer: Sergei Avdeyev, Russian Space Agency

Cosmonaut-Researcher: Thomas Reiter, European Space Agency

Mission Duration: 192 hours (8 days), 4 hours, 31 minutes, 42 seconds

Miles Traveled: Approximately 3.4 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 129

Orbital Altitude: 160 nautical miles (184 statute miles) insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 2,471 feet beyond threshold

Landing Rollout: Approximately 8,691 feet

Orbiter Weight at Landing: Approximately 204,375 pounds

Lift-off Weight: Approximately 4,511,797 pounds

Orbiter Weight at Lift-off: Approximately 247,709 pounds

Landing Speed at Main Gear Touchdown: Approximately 196 knots (226 miles per hour)

Payload Weight Up: Approximately 13,525 pounds

Payload Weight Down: Approximately 3,938 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Shuttle-Mir Mission 2; docking module with two attached solar arrays; IMAX Cargo Bay Camera (ICBC); Glow Experiment (GLO-4)/ Photogrammetric Appendage Structural Dynamics Experiment (PASDE) Payload (GPP); Shuttle Amateur Radio Experiment (SAREX) II

STS-72 Mission Facts — Endeavour — January 11–20, 1996

Commander: Brian K. Duffy

Pilot: Brent W. Jett, Jr.

Mission Specialist 1: Leroy Chiao

Mission Specialist 2: Winston E. Scott

Mission Specialist 3: Koichi Wakata, National Space Development Agency of Japan

Mission Specialist 4: Daniel T. Barry

Mission Duration: 192 hours (8 days), 22 hours, 1 minute, 47 seconds

Miles Traveled: Approximately 3.7 million statute miles

Inclination: 28.45 degrees

Orbits of Earth: 142

Orbital Altitude: 250 nautical miles (288 statute miles)

Landing Touchdown: Approximately 3,386 feet beyond threshold

Landing Rollout: Approximately 8,070 feet

Orbiter Weight at Landing: Approximately 217,269 pounds

Lift-off Weight: Approximately 4,514,955 pounds

Orbiter Weight at Lift-off: Approximately 247,319 pounds

Landing Speed at Main Gear Touchdown: Approximately 185 knots (213 miles per hour)

Payload Weight Up: Approximately 14,353 pounds

Payload Weight Down: Approximately 22,233 pounds

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: Space Flyer Unit (SFU) retrieval; Office of Aeronautics and Space Technology (OAST) Flyer; Shuttle Solar Backscatter Ultraviolet (SSBUV/A; Shuttle Laser Altimeter (SLA) 01/ Getaway Special (GAS)(5); Extravehicular Activity Development Flight Test (EDFT) 03; Physiological and Anatomical Rodent Experiment (PARE)/ National Institutes of Health (NIH) Rodents (R) 03; Protein Crystal Growth (PCG) Single-Locker Thermal Enclosure System (STES) 04; Commercial Protein Crystal Growth (CPCG) 08; Space Tissue Loss (STL)/National Institutes of Health (NIH) Cells (C) 05

Extravehicular Activity (EVA): EVA No. 1, Leroy Chiao and Daniel T. Barry, 6 hours, 9 minutes; EVA No. 2, Leroy Chiao and Winston E. Scott, 6 hours, 53 minutes. Chiao and Barry evaluated a new EVA workstation, a movable stanchion that provides stability for astronauts and holders for tools, a flexible foot restraint, and a rigid umbilical that may be used on the International Space Station to hold fluid and electrical umbilicals in place.

STS-72 Mission Facts (Cont)

Chiao and Scott evaluated a utility box designed to hold avionics and fluid line connections on the space station, an on-orbit-installed slidewire to which tethers can be connected, thermal improvements of space suits, and a wrist-mounted computer called the electronic cuff checklist. They also took measurements of the forces induced by work.

STS-75 Mission Facts — Columbia — February 22–March 9, 1996

Commander: Andrew M. Allen

Pilot: Scott J. "Doc" Horowitz

Payload Commander: Franklin R. Chang-Diaz

Mission Specialist 1: Jeffrey A. Hoffman

Mission Specialist 2: Maurizio Cheli, European Space Agency

Mission Specialist 3: Claude Nicollier, European Space Agency

Payload Specialist: Umberto Guidoni, Italian Space Agency

Mission Duration: 360 hours (15 days), 17 hours, 40 minutes, 21 seconds

Miles Traveled: Approximately 6.5 million statute miles

Inclination: 28.45 degrees

Orbits of Earth: 252

Orbital Altitude: 160 nautical miles (184 statute miles)

Landing Touchdown: Approximately 2,175 feet beyond threshold

Landing Rollout: Approximately 8,460 feet

Orbiter Weight at Landing: 228,571 pounds

Lift-off Weight: Approximately 4,526,493 pounds

Orbiter Weight at Lift-off: Approximately 261,491 pounds

Landing Speed at Main Gear Touchdown: Approximately 189 knots (217 miles per hour)

Payload Weight Up: Approximately 23,353 pounds

Payload Weight Down: 23,263 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Tethered Satellite System (TSS) Reflight (1R); Orbital Acceleration Research Experiment (OARE) (part of United States Microgravity Payload 3); USMP-3; Commercial Protein Crystal Growth (CPCG) 09, Block IV; Middeck Glovebox Experiment (MGBX) (part of USMP-3)

During the deployment of TSS, the tether broke and the satellite was lost.

STS-76 Mission Facts — Atlantis — March 22–31, 1996

Commander: Kevin P. Chilton
Pilot: Richard A. Searfoss
Mission Specialist: Shannon W. Lucid—up only
Mission Specialist: Linda M. Godwin
Mission Specialist: Michael R. "Rich" Clifford
Mission Specialist: Ronald M. Sega
Mission Duration: 216 hours (9 days), 5 hours, 16 minutes, 48 seconds
Miles Traveled: Approximately 3.8 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 145
Orbital Altitude: 160 nautical miles (184 statute miles) insertion; 213 nautical miles (245 statute miles) for Mir rendezvous
Landing Touchdown: Approximately 2,222 feet beyond threshold
Landing Rollout: Approximately 8,357 feet
Orbiter Weight at Landing: Approximately 210,316 pounds
Lift-off Weight: Approximately 4,509,503 pounds
Orbiter Weight at Lift-off: Approximately 246,345 pounds
Landing Speed at Main Gear Touchdown: Approximately 204 knots (235 miles per hour)
Payload Weight Up: Approximately 14,888 pounds
Payload Weight Down: Approximately 12,058 pounds
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payloads: Shuttle-Mir Mission 3; SPACEHAB/Mir 03; KidSat; Shuttle Amateur Radio Experiment (SAREX) II, Configuration M; RME 1304—Mir/Environmental Effects Payload (MEEP); orbiter docking system; RME 1315—Trapped Ions in Space Experiment (TRIS); Extravehicular Activity Development Flight Test (EDFT) 04
Extravehicular Activity (EVA): Linda M. Godwin and Michael R. "Rich" Clifford, 6 hours, 2 minutes, 28 seconds. Godwin and Clifford attached four experiments, known collectively as MEEP, onto handrails located on Mir's docking module. They also detached a television camera from the outside of the Mir docking module to return it to Earth, and evaluated a variety of new spacewalking tools capable of being used on both the U.S. and Russian spacecraft.

STS-77 Mission Facts — Endeavour — May 19–29, 1996

Commander: John H. Casper
Pilot: Curtis L. Brown, Jr.
Mission Specialist: Daniel W. Bursch
Mission Specialist: Andrew S.W. Thomas
Mission Specialist: Marc Garneau, Canadian Space Agency
Mission Specialist: Mario Runco, Jr.
Mission Duration: 240 hours (10 days), 0 hours, 40 minutes, 10 seconds
Miles Traveled: Approximately 4.1 million statute miles
Inclination: 39 degrees
Orbits of Earth: 161
Orbital Altitude: 153 nautical miles (176 statute miles)
Landing Touchdown: Approximately 1,688 feet beyond threshold
Landing Rollout: Approximately 9,290 feet
Orbiter Weight at Landing: Approximately 221,382 pounds
Lift-off Weight: Approximately 4,518,947 pounds
Orbiter Weight at Lift-off: Approximately 254,538 pounds
Landing Speed at Main Gear Touchdown: Approximately 215 knots (247 miles per hour)
Payload Weight Up: Approximately 26,971 pounds
Payload Weight Down: Approximately 26,149 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Shuttle Pointed Research Tool for Astronomy (SPARTAN) 207/Inflatable Antenna Experiment (IAE); Technology Experiments Advancing Missions in Space (TEAMS) 01 (includes Vented Tank Resupply Experiment [VTRE], Global Positioning System [GPS] Attitude and Navigation Experiment [GANE] [RME 1316], Liquid Metal Test Experiment [LMTE] and Passive Aerodynamically Stabilized Magnetically Damped Satellite [PAMS] Satellite Test Unit [STU]; SPACEHAB-4; Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment (BETSCE); 12 getaway specials attached to a GAS bridge assembly (GAS 056, 063, 142, 144, 163, 200, 490, 564, 565, 703, 741 and the Reduced-Fill Tank Pressure Control Experiment [RFTPCE]; Aquatic Research Facility (ARF) 01; Biological Research in Canisters (BRIC) 07, Block III

STS-78 Mission Facts – Columbia
June 20–July 7, 1996

Commander: Terence T. "Tom" Henricks
Pilot: Kevin R. Kregel
Mission Specialist: Susan J. Helms
Mission Specialist: Richard M. Linnehan

STS-78 Mission Facts (Cont)

Mission Specialist: Charles E. Brady, Jr.
Payload Specialist: Jean-Jacques Favier, French Atomic Energy Commission (CEA), French Space Agency (CNES)
Payload Specialist: Robert Brent Thirsk, Canadian Space Agency
Mission Duration: 384 hours (16 days), 21 hours, 48 minutes, 30 seconds
Miles Traveled: Approximately 7 million statute miles
Inclination: 39 degrees
Orbits of Earth: 272
Orbital Altitude: 150 nautical miles (173 statute miles)
Landing Touchdown: Approximately 2,304 feet beyond threshold
Landing Rollout: Approximately 9,290 feet
Orbiter Weight at Landing: Approximately 228,009 pounds
Lift-off Weight: Approximately 4,517,981 pounds
Orbiter Weight at Lift-off: Approximately 254,823 pounds
Landing Speed at Main Gear Touchdown: Approximately 208 knots (239 mph)
Payload Weight Up: Approximately 23,537 pounds
Payload Weight Down: Approximately 23,537 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Life and Microgravity Sciences (LMS) 01 Spacelab with long crew transfer tunnel; Orbital Acceleration Research Experiment (OARE); extended-duration orbiter cryogenic pallet; Biological Research in Canisters (BRIC) 8, Block II; Shuttle Amateur Radio Experiment (SAREX) II, Configuration C

STS-79 Mission Facts – Atlantis – September 16–26, 1996

Commander: William F. Readdy
Pilot: Terrence W. Wilcutt
Mission Specialist: Thomas D. Akers
Mission Specialist: Jerome Apt
Mission Specialist: Carl E. Walz
Mission Specialist: John E. Blaha—up only
Mir Crew Member: Shannon W. Lucid—down only
Mission Duration: 240 hours (10 days), 3 hours, 18 minutes, 24 seconds
Miles Traveled: Approximately 3.9 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 160
Orbital Altitude: 170 nautical miles (196 statute miles) insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

STS-79 Mission Facts (Cont)

Landing Touchdown: Approximately 807 feet beyond threshold
Landing Rollout: Approximately 10,981 feet
Orbiter Weight at Landing: Approximately 215,176 pounds
Lift-off Weight: Approximately 4,510,356 pounds
Orbiter Weight at Lift-off: Approximately 249,327 pounds
Landing Speed at Main Gear Touchdown: Approximately 217 knots (250 miles per hour)
Payload Weight Up: Approximately 19,516 pounds
Payload Weight Down: Approximately 18,346 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Florida
Payloads: Shuttle/Mir Mission 04; SPACEHAB/Mir 05; orbiter docking system; Shuttle/Mir Mission 04 middeck science; Shuttle Amateur Radio Experiment (SAREX) II, configuration M; IMAX in-cabin camera; Midcourse Space Experiment (MSX)

STS-80 Mission Facts – Columbia – November 19–December 7, 1996

Commander: Kenneth D. Cockrell
Pilot: Kent V. Rominger
Mission Specialist: Tamara E. Jernigan
Mission Specialist: Thomas David Jones
Mission Specialist: F. Story Musgrave
Mission Duration: 408 hours (17 days), 15 hours, 54 minutes, 28 seconds
Miles Traveled: Approximately 7.6 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 279
Orbital Altitude: 190 nautical miles (219 statute miles)
Landing Touchdown: Approximately 3,084 feet beyond threshold
Landing Rollout: Approximately 8,705 feet
Orbiter Weight at Landing: Approximately 227,879 pounds
Lift-off Weight: Approximately 4,525,340 pounds
Orbiter Weight at Lift-off: Approximately 261,910 pounds
Landing Speed at Main Gear Touchdown: Approximately 371 knots (427 miles per hour)
Payload Weight Up: Approximately 21,489 pounds
Payload Weight Down: Approximately 21,387 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida

STS-80 Mission Facts (Cont)

Payloads: Wake Shield Facility (WSF) 03; Orbiting and Retrievable Far and Extreme Ultraviolet Spectrograph—Shuttle Pallet Satellite (ORFEUS-SPAS) II; Inter-Mars Tissue Equivalent Proportional Counter (ITEPC) (also known as DSO 485); Extravehicular Activity Development Flight Test (EDFT) 05; Space Experiment Module (SEM) 01/Getaway Special (GAS); Physiological and Anatomical Rodent Experiment (PARE)/National Institutes of Health (NIH)-Rodents (R) 04; Commercial Materials Dispersions Apparatus (MDA) Instrumentation Technology Associates (ITA) Experiments (CMIX) 05, Configuration B; Visualization in an Experimental Water Capillary Pumped Loop (VIEW-CPL); Cell Culture Module (CCM), Configuration A; Biological Research in Canisters (BRIC) 09, Block 1; Midcourse Space Experiment (payload of opportunity) Due to problems in opening Columbia's airlock hatch, EDFT 05 could not be performed and no extravehicular activity occurred.

STS-81 Mission Facts – Atlantis – January 12–22, 1997

Commander: Michael A. Baker

Pilot: Brent W. Jett, Jr.

Mission Specialist: John M. Grunsfeld

Mission Specialist: Marsha S. Ivins

Mission Specialist: Peter J.K. "Jeff" Wisoff

Mission Specialist: Jerry M. Linenger—up only

Mir Crew Member: John E. Blaha—down only

Mission Duration: 240 hours (10 days), 4 hours, 56 minutes, 31 seconds

Miles Traveled: Approximately 3.8 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 161

Orbital Altitude: 160 nautical miles (184 statute miles) insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 2,926 feet beyond threshold

Landing Rollout: Approximately 9,417 feet

Orbiter Weight at Landing: Approximately 214,452 pounds

Lift-off Weight: Approximately 4,510,780 pounds

Orbiter Weight at Lift-off: Approximately 249,936 pounds

Landing Speed at Main Gear Touchdown: Approximately 369 knots (425 miles per hour)

Payload Weight Up: Approximately 19,321 pounds

STS-81 Mission Facts (Cont)

Payload Weight Down: Approximately 18,144 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: SPACEHAB 06 double module, orbiter docking system, Shuttle/Mir Mission 05 middeck science, Midcourse Space Experiment (MSX), Cosmic Radiation Effects and Activation Monitor (CREAM), KidSat

STS-82 Mission Facts – Discovery – February 11–21, 1997

Commander: Kenneth D. Bowersox
Pilot: Scott J. "Doc" Horowitz
Mission Specialist: Mark C. Lee
Mission Specialist: Gregory J. Harbaugh
Mission Specialist: Steven L. Smith
Mission Specialist: Joseph R. Tanner
Mission Specialist: Steven A. Hawley
Mission Duration: 216 hours (9 days), 23 hours, 38 minutes, 9 seconds
Miles Traveled: Approximately 4.1 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 150
Orbital Altitude: 313 nautical miles (360 statute miles) orbital insertion; 320 nautical miles (369 statute miles) rendezvous
Landing Touchdown: Approximately 2,607 feet beyond threshold
Landing Rollout: Approximately 7,073 feet
Orbiter Weight at Landing: Approximately 214,014 pounds
Lift-off Weight: Approximately 4,514,520 pounds
Orbiter Weight at Lift-off: Approximately 251,371 pounds
Landing Speed at Main Gear Touchdown: Approximately 184 knots (212 miles per hour)
Payload Weight Up: Approximately 16,735 pounds
Payload Weight Down: Approximately 16,429 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Florida
Payloads: Hubble Space Telescope Servicing Mission 02 (second axial carrier, orbital replacement unit carrier, flight support system); Midcourse Space Experiment
Extravehicular Activity (EVA): EVA 1, Mark C. Lee and Steven L. Smith, 6 hours, 42 minutes; EVA 2, Gregory J. Harbaugh and Joseph R. Tanner, 7 hours, 27 minutes; EVA 3, Mark C. Lee and Steven L. Smith, 7 hours, 11 minutes; EVA 4,

STS-82 Mission Facts (Cont)

Gregory J. Harbaugh and Joseph R. Tanner, 6 hours, 34 minutes; EVA 5, Mark C. Lee and Steven L. Smith, 5 hours, 17 minutes. During EVA 1, Lee and Smith removed and replaced the Goddard high-resolution spectrograph and the faint-object spectrograph with the new space telescope imaging spectrograph and the near-infrared camera and multiobject spectrometer, respectively. During EVA 2, Harbaugh and Tanner replaced a degraded fine guidance sensor and a failed engineering and science tape recorder with new spares. They installed a new unit known as the optical control electronics enhancement kit. During EVA 3, Lee and Smith removed and replaced a data interface unit and replaced an old reel-to-reel engineering and science tape recorder with a new digital solid-state recorder. They also changed out one of Hubble's four reaction wheel assembly units. During EVA 4, Harbaugh and Tanner replaced a solar array drive electronics package and covers over Hubble's magnetometers. They then placed thermal blankets of multilayer material over two areas of degraded insulation around the light shield portion of the telescope just below the top of the astronomical observatory. During EVA 5, Lee and Smith attached several thermal insulation blankets to three equipment compartments at the top of the support systems module section of Hubble. The compartments contain key data processing, electronics and scientific instrument telemetry packages. Over the course of the mission, Hubble was also reboosted into an orbit approximately 8 nautical miles higher.

STS-83 Mission Facts — Columbia — April 4–8, 1997

Commander: James D. Halsell, Jr.
Pilot: Susan L. Still
Payload Commander: Janice Voss
Mission Specialist: Donald A. Thomas
Mission Specialist: Michael L. Gernhardt
Payload Specialist: Roger K. Crouch
Payload Specialist: Gregory T. Linteris
Mission Duration: 72 hours (3 days), 23 hours, 13 minutes, 38 seconds
Miles Traveled: Approximately 1.5 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 63
Orbital Altitude: 160 nautical miles (184 statute miles)
Landing Touchdown: Approximately 3,174 feet beyond threshold
Landing Rollout: Approximately 8,623 feet

STS-83 Mission Facts (Cont)

Orbiter Weight at Landing: Approximately 213,060 pounds

Lift-off Weight: Approximately 4,523,076 pounds

Orbiter Weight at Lift-off: Approximately 259,927 pounds

Landing Speed at Main Gear Touchdown: Approximately 193 knots (222 miles per hour)

Payload Weight Up: Approximately 25,530 pounds

Payload Weight Down: Approximately 25,530 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Microgravity Science Laboratory (MSL) 01, Spacelab module with long crew transfer tunnel, extended-duration orbiter cryogenic pallet, Cryogenic Flexible Diode Heat Pipe Experiment (CRYOFD), Orbital Acceleration Research Experiment (OARE), Protein Crystal Growth (PCG)—Single-Locker Thermal Enclosure System (STES), Shuttle Amateur Radio Experiment (SAREX) II, Midcourse Space Experiment (MSX)

The mission was cut short by Shuttle managers due to a problem with fuel cell No. 2, which displayed evidence of internal voltage degradation after the launch.

STS-84 Mission Facts — Atlantis — May 15–24, 1997

Commander: Charles J. Precourt

Pilot: Eileen Marie Collins

Mission Specialist: Jerry M. Linenger (down only)

Mission Specialist: C. Michael Foale (up only)

Mission Specialist: Elena V. Kondakova, RSC Energia

Mission Specialist: Carlos I. Noriega

Mission Specialist: Edward T. Lu

Mission Specialist: Jean-Francois Clervoy, European Space Agency

Mission Duration: 216 hours (9 days), 5 hours, 20 minutes, 47 seconds

Miles Traveled: Approximately 3.6 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 144

Orbital Altitude: 160 nautical miles (184 statute miles) insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 3,153 feet beyond threshold

Landing Rollout: Approximately 8,201 feet

Orbiter Weight at Landing: Approximately 213,865 pounds

Lift-off Weight: Approximately 4,509,832 pounds

STS-84 Mission Facts (Cont)

Orbiter Weight at Lift-off: Approximately 249,624 pounds

Landing Speed at Main Gear Touchdown: Approximately 210 knots (242 miles per hour)

Payload Weight Up: Approximately 19,779 pounds

Payload Weight Down: Approximately 19,387 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: SPACEHAB 07 double module/Mir 06, transfer tunnel, transfer tunnel extension, orbiter docking system, European Space Agency proximity operations sensor (EPS), Shuttle/Mir Mission 06 middeck science, Cosmic Radiation Effects and Activation Monitor (CREAM), Radiation Monitoring Equipment (RME) III, Shuttle Ionospheric Modification With Pulsed Local Exhaust (SIMPLEX) Liquid Motion Experiment (LME), Protein Crystal Growth (PCG)—Single-Locker Thermal Enclosure System (STES), Midcourse Space Experiment (MSX), Electrolysis Performance Improvement Concept Study (EPICS)

STS-94 Mission Facts — Columbia — July 1–17, 1997

Commander: James D. Halsell, Jr.

Pilot: Susan L. Still

Mission Specialist: Donald A. Thomas

Mission Specialist: Janice Voss

Mission Specialist: Michael L. Gernhardt

Payload Specialist: Gregory T. Linteris

Payload Specialist: Roger K. Crouch

Mission Duration: 360 hours (15 days), 16 hours, 45 minutes, 29 seconds

Miles Traveled: Approximately 6.2 million statute miles

Inclination: 28.45 degrees

Orbits of Earth: 251

Orbital Altitude: 160 nautical miles (184 statute miles)

Landing Touchdown: Approximately 3,133 feet beyond threshold

Landing Rollout: Approximately 8,910 feet

Orbiter Weight at Landing: Approximately 230,292 pounds

Lift-off Weight: Approximately 4,523,389 pounds

Orbiter Weight at Lift-off: Approximately 260,266 pounds

Landing Speed at Main Gear Touchdown: Approximately 208 knots (239 miles per hour)

Payload Weight Up: Approximately 25,568 pounds

Payload Weight Down: Approximately 25,568 pounds

STS-94 Mission Facts (Cont)

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: First Microgravity Science Laboratory (MSL) 01; Spacelab module with long crew transfer tunnel; Extended-Duration Orbiter Cryogenic Pallet; Cryogenic Flexible Diode Heat Pipe Experiment (CRYOFD); Orbiter Acceleration Research Experiment (OARE); Protein Crystal Growth (PCG)—Single-Locker Thermal Enclosure System (STES); Shuttle Amateur Radio Experiment (SAREX) II; Midcourse Space Experiment (MSX)—payload of opportunity with no onboard hardware

STS-85 Mission Facts — Discovery— August 7–19, 1997

Commander: Curtis L. Brown, Jr.

Pilot: Kent Rominger

Mission Specialist: N. Jan Davis

Mission Specialist: Robert L. Curbeam, Jr.

Mission Specialist: Stephen K. Robinson

Payload Specialist: Bjarni Tryggvason, Canadian Space Agency

Mission Duration: 264 hours (11 days), 20 hours, 28 minutes, 7 seconds

Miles Traveled: Approximately 4.7 million statute miles

Inclination: 57 degrees

Orbits of Earth: 190

Orbital Altitude: 160 nautical miles (184 statute miles)

Landing Touchdown: Approximately 3,074 feet beyond threshold

Landing Rollout: Approximately 8,745 feet

Orbiter Weight at Landing: Approximately 219,571 pounds

Lift-off Weight: Approximately 4,512,125 pounds

Orbiter Weight at Lift-off: Approximately 250,101 pounds

Landing Speed at Main Gear Touchdown: Approximately 185 knots (213 miles per hour)

Payload Weight Up: Approximately 24,982 pounds

Payload Weight Down: Approximately 24,843 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA)—Shuttle Pallet Satellite (SPAS) II; International Extreme Ultraviolet Hitchhiker (IEH) 02; Manipulator Flight Demonstration (MFD); Technology Applications and Science (TAS) 01; Getaway Specials 572 and 745; MFD aft flight deck equipment; Bioreactor

STS-85 Mission Facts (Cont)

Demonstration System (BDS) 03, Configuration B; Biological Research in Canisters (BRIC) 10; Shuttle Ionospheric Modification With Pulsed Local Exhaust (SIMPLEX); Protein Crystal Growth (PCG)—Single-Locker Thermal Enclosure System (STES) 05; Advanced X-Ray Astrophysics Facility—Imaging (AXAF) Charge Coupled Device (CCD) Imaging Spectrometer (ACIS); Midcourse Space Experiment (MSX)—payload of opportunity with no onboard hardware; Southwest Ultraviolet Imaging System (SWIS); Solid Surface Combustion Experiment (SSCE)

STS-86 Mission Facts – Atlantis – September 25–October 6, 1997

Commander: James D. Wetherbee

Pilot: Michael J. Bloomfield

Mission Specialist: Vladimir Georgievich Titov, Russian Space Agency

Mission Specialist: Scott E. Parazynski

Mission Specialist: Jean-Loup J. M. Chretien, French Space Agency

Mission Specialist: Wendy B. Lawrence

Mission Specialist: David A. Wolf—up only

Mission Specialist: C. Michael Foale—down only

Mission Duration: 240 hours (10 days), 19 hours, 22 minutes, 12 seconds

Miles Traveled: Approximately 4,225,000 statute miles

Inclination: 51.6 degrees

Orbits of Earth: 170

Orbital Altitude: 160 nautical miles (184 statute miles) at insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 2,490 feet beyond threshold

Landing Rollout: Approximately 11,956 feet

Orbit Weight at Landing: Approximately 213,979 pounds

Lift-off Weight: Approximately 4,514,278 pounds

Orbiter Weight at Lift-off: Approximately 251,518 pounds

Landing Speed at Main Gear Touchdown: Approximately 198 knots (228 miles per hour)

Payload Weight Up: Approximately 20,531 pounds

Payload Weight Down: Approximately 20,079 pounds

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: SPACEHAB double module/Mir 07; transfer tunnel; transfer tunnel extension; orbiter docking system; RME1314: European Space Agency Proximity Operations Sensor (EPS); Seeds in

STS-86 Mission Facts (Cont)

Space (SEEDS) II; MEEP carriers; Shuttle/Mir Mission 07 middeck science; Cosmic Radiation Effects and Activation Monitor (CREAM); KidSat; Commercial Protein Crystal Growth (CPCG); Cell Culture Module (CCM) A; Risk Mitigation Experiments

Extravehicular Activity (EVA): Scott E. Parazynski and Vladimir Georgievich Titov, Russian Space Agency, 5 hours, 1 minute. During this first U.S. spacewalk to include participation by a foreign astronaut, Parazynski and Titov retrieved MEEP and tested hardware for future EVA activities, including an evaluation of the Simplified Aid for EVA Rescue (SAFER), a small jet-backpack designed for use as a type of life jacket during station assembly. They also retrieved a solar array cap to be placed on the damaged Spektr module to the exterior of the docking module.

STS-87 Mission Facts — Columbia — November 19–December 5, 1997

Commander: Kevin R. Kregel

Pilot: Steven W. Lindsey

Mission Specialist: Kalpona Chawla

Mission Specialist: Winston E. Scott

Mission Specialist: Takao Doi, National Space Development Agency of Japan

Payload Specialist: Leonid Kadenyuk, National Space Agency of Ukraine

Mission Duration: 360 hours (15 days), 16 hours, 35 minutes, 1 second

Miles Traveled: Approximately 6.5 million statute miles

Inclination: 28.45 degrees

Orbits of Earth: 252

Orbital Altitude: 150 nautical miles (173 statute miles)

Landing Touchdown: Approximately 2,635 feet beyond threshold

Landing Rollout: Approximately 8,003 feet

Orbiter Weight at Landing: Approximately 231,625 pounds

Lift-off Weight: Approximately 4,523,442 pounds

Orbiter Weight at Lift-off: Approximately 260,799 pounds

Landing Speed at Main Gear Touchdown: Approximately 188 knots (216 miles per hour)

Payload Weight Up: Approximately 22,130 pounds

Payload Weight Down: Approximately 22,130 pounds

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201-04; United States Microgravity Payload (SMP) 4; Extravehicular

STS-87 Mission Facts (Cont)

Activity (EVA) Demonstration Flight Test (EDFT) 05; Shuttle Ozone Limb Sounding Experiment (SOLSE); Loop Heat Pipe (LHP); Sodium Sulfur Battery Experiment (NaSBE); Turbulent Gas Jet Diffusion Flames (TGDF); Getaway Special (GAS) 036; Shuttle Ionospheric Modification With Pulsed Local Exhaust (SIMPLEX); Collaborative Ukraine Experiment (CUE); Autonomous EVA Robotic (AER) Camera/Sprint; Midcourse Space Experiment (MSX)

Extravehicular Activity (EVA): EVA 1, Winston Scott and Takao Doi, 7 hours, 43 minutes; EVA 2, Winston Scott and Takao Doi, 4 hours, 59 minutes, 40 seconds. During EVA 1, Scott and Doi manually captured the SPARTAN satellite, whose attitude control system had failed following its release from Columbia's robot arm on November 21. The two also evaluated equipment and procedures that will be used with future International Space Station operations. During EVA 2, Scott and Doi completed tasks originally planned for the mission's first spacewalk. They also used the SPARTAN satellite as a laser target to prepare for future automatic spacecraft dockings. In addition, they tested the AER Camera/Sprint, a free-flying video camera designed to perform remote inspections of the Shuttle or station.

STS-89 Mission Facts — Endeavour — January 22–31, 1998

Commander: Terrence W. Wilcutt

Pilot: Joe Frank Edwards, Jr.

Mission Specialist: James F. Reilly, II

Mission Specialist: Michael P. Anderson

Mission Specialist/Payload Commander: Bonnie J. Dunbar

Mission Specialist: Salizhan Shakirovich Sharipov, Russian Space Agency

Mission Specialist: Andrew S.W. Thomas

Mission Specialist: David A. Wolf

Mission Duration: 192 hours (8 days), 19 hours, 48 minutes, 4 seconds

Miles Traveled: Approximately 3.6 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 139

Orbital Altitude: 160 nautical miles (184 statute miles) at insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 2,796 feet beyond threshold

Landing Rollout: Approximately 9,769 feet

Orbiter Weight at Landing: Approximately 216,241 pounds

STS-89 Mission Facts (Cont)

Lift-off Weight: Approximately 4,512,608 pounds
Orbiter Weight at Lift-off: Approximately 251,692 pounds
Landing Speed at Main Gear Touchdown: Approximately 202 knots (232 miles per hour)
Payload Weight Up: Approximately 21,940 pounds
Payload Weight Down: Approximately 19,529 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Florida
Payloads: SPACEHAB 08 double module/Mir 08; transfer tunnel; transfer tunnel extension; orbiter docking system; Getaway Specials 093, 141, 145, and 432; Phase 1 requirements (Shuttle/Mir Mission 08 middeck science, mission support equipment and risk mitigation experiments); cosmic radiation effects and activation monitor (CREAM); Shuttle ionospheric modification with pulsed local exhaust (SIMPLEX) payload of opportunity; EarthKAM (also known as KidSat); microgravity plant nutrient experiment (MPNE); human performance (HP) experiment; closed equilibrated biological aquatic system (CEBAS); DTOs; and DSOs

STS-90 Mission Facts — Columbia — April 17–May 3, 1998

Commander: Richard A. Searfoss
Pilot: Scott D. Altman
Mission Specialist: Kathryn "Kay" Hire
Mission Specialist: Richard M. Linnehan
Mission Specialist: Dafydd (Dave) Rhys Williams, Canadian Space Agency
Payload Specialist: Dr. Jay C. Buckey
Payload Specialist: Dr. James A. Pawelczyk
Mission Duration: 360 hours (15 days), 21 hours, 50 minutes, 58 seconds
Miles Traveled: Approximately 6.375 million statute miles
Inclination: 39 degrees
Orbits of Earth: 256
Orbital Altitude: 150 nautical miles (173 statute miles)
Landing Touchdown: Approximately 1,694 feet beyond threshold
Landing Rollout: Approximately 9,949 feet
Orbiter Weight at Landing: Approximately 231,113 pounds
Lift-off Weight: Approximately 4,523,770 pounds
Orbiter Weight at Lift-off: Approximately 262,357 pounds
Landing Speed at Main Gear Touchdown: Approximately 224 knots (258 miles per hour)
Payload Weight Up: Approximately 26,150 pounds
Payload Weight Down: Approximately 26,150 pounds

STS-90 Mission Facts (Cont)

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payloads: Neurolab; Getaway Specials 197, 744 and 772; Shuttle Vibration Forces (SVFs); extended duration orbiter (EDO) cryogenic pallet; Bioreactor Demonstration System (BDS) 04; DTOs and DSOs

STS-91 Mission Facts — Discovery— June 2–12, 1998

Commander: Charles (Charlie) J. Precourt

Pilot: Dominic (Dom) L. Gorie

Mission Specialist: Franklin Chang-Diaz

Mission Specialist: Wendy Lawrence

Mission Specialist: Janet Kavandi

Mission Specialist: Valeriy Ryumin, Russian Space Agency

Mission Specialist: Andrew (Andy) S.W. Thomas—down only

Mission Duration: 216 hours (9 days), 19 hours, 55 minutes, 1 second

Miles Traveled: Approximately 3.8 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 155

Orbital Altitude: 173 nautical miles (199 statute miles) at insertion; 213 nautical miles (245 statute miles) for Mir rendezvous

Landing Touchdown: Approximately 1,309 feet beyond threshold

Landing Rollout: Approximately 10,730 feet

Orbiter Weight at Landing: Approximately 225,276 pounds

Lift-off Weight: Approximately 4,514,510 pounds

Orbiter Weight at Lift-off: Approximately 259,834 pounds

Landing Speed at Main Gear Touchdown: Approximately 214 knots (246 miles per hour)

Payload Weight Up: Approximately 25,922 pounds

Payload Weight Down: Approximately 26,109 pounds

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: SPACEHAB 09 single module/Mir 09; orbiter docking system; getaway specials (8): G-090, G-743, G-765, G-648, two Space Experiment Modules (SEMs) (SEM 03 and SEM 05), two Phase 1 Program Support Packages (PH1 PSP1 and PH1 PSP2); Alpha Magnetic Spectrometer (AMS); Phase 1 requirements (Shuttle/Mir Mission 09 middeck science, mission support equipment and risk mitigation experiments); Commercial Protein Crystal Growth (CPCG); Solid Surface Combustion Experiment (SSCE); Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX, payload of opportunity; DTOs, DSO, RMEs and HTD

STS-95 Mission Facts — Discovery—
October 29–November 7, 1998

Commander: Curtis L. Brown, Jr.

Pilot: Steven W. Lindsey

Mission Specialist: Scott E. Parazynski

Mission Specialist: Stephen K. Robinson

Mission Specialist: Pedro Duque, European Space Agency

Payload Specialist: Chiaki Mukai, National Space Development Agency of Japan

Payload Specialist: Senator John Glenn

Mission Duration: 192 hours (8 days), 21 hours, 44 minutes, 56 seconds

Miles Traveled: Approximately 3.6 million statute miles

Inclination: 28.45 degrees

Orbits of Earth: 135

Orbital Altitude: 300 nautical miles (345 statute miles)

Orbiter Weight at Landing: Approximately 227,783 pounds

Lift-off Weight: Approximately 4,521,918 pounds

Orbiter Weight at Lift-off: Approximately 227,207 pounds

Payload Weight Up: Approximately 28,520 pounds

Payload Weight Down: Approximately 28,367 pounds

Landing Touchdown: Approximately 3,333 feet beyond threshold

Landing Rollout: Approximately 9,511 feet

Landing Speed at Main Gear Touchdown: Approximately 199 knots (229 miles per hour)

Landed: Kennedy Space Center, Florida

Payloads: SPACEHAB; SPARTAN 201-5; Hubble Space Telescope Orbital Systems Test Platform (HOST); International Extreme Ultraviolet Hitchhiker (IEH)-3; Cryogenic Thermal Storage Unit (CRYOTSU); Space Experiment Module (SEM)-4; Getaway Special (GAS) program; Biological Research in Canisters (BRIC); Electronic Nose (E-NOSE)

STS-88 Mission Facts — Endeavour—
December 4–15, 1998

Commander: Robert D. Cabana

Pilot: Frederick W. "Rick" Sturckow

Mission Specialist: Nancy J. Currie

Mission Specialist: Jerry L. Ross

Mission Specialist: James H. Newman

Mission Specialist: Sergei Konstantinovich Krikalev, Russian Space Agency

Mission Duration: 264 hours (11 days), 19 hours, 18 minutes, 47 seconds

STS-88 Mission Facts (Cont)

Miles Traveled: Approximately 4.6 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 186

Orbital Altitude: 173 nautical miles (199 statute miles)

Orbiter Weight at Landing: Approximately 200,296 pounds

Lift-off Weight: Approximately 4,518,390 pounds

Orbiter Weight at Lift-off: Approximately 263,927 pounds

Payload Weight Up: Approximately 30,986 pounds

Payload Weight Down: Approximately 4,500 pounds

Landing Touchdown: Approximately 3,291 feet beyond threshold

Landing Rollout: Approximately 8,322 feet

Landing Speed at Main Gear Touchdown: Approximately 197 knots (227 miles per hour)

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: ISS Unity connecting module; IMAX cargo bay camera (ICBC); Satelite de Aplicaciones/ Cientifico A (SAC-A); MightySat 1; Space Experiment Module (SEM) 07; getaway special (G-093)

Extravehicular Activity (EVA): EVA 1, Jerry Ross and Jim Newman, 7 hours, 21 minutes; EVA 2, Jerry Ross and Jim Newman, 7 hours, 2 minutes; EVA 3, Jerry Ross and Jim Newman, 6 hours, 59 minutes. During EVA 1, Ross and Newman made all umbilical connections necessary to activate Node 1. Upon completion, the ground sent commands to the node to confirm power and activation. During EVA 2, Ross and Newman installed EVA translation aids and tools and early communications system antennas and routed the comm cable from the FGB to the starboard antenna. EVA 3 was performed to support objectives of downstream assembly missions. Tasks included installation of a large tool bag for storing EVA tools outside the station and repositioning foot restraints. Additionally, Ross and Newman disconnected the umbilical on PMA-2 so that PMA-2 can be relocated in the future.

STS-96 Mission Facts — Discovery — May 27–June 6, 1999

Commander: Kent V. Rominger

Pilot: Rick D. Husband

Mission Specialist: Ellen Ochoa

Mission Specialist: Tamara E. Jernigan

Mission Specialist: Daniel T. Barry

Mission Specialist: Julie Payette, Canadian Space Agency

Mission Specialist: Valery Ivanovich Tokarev, Russian Space Agency

Mission Duration: 216 hours (9 days), 19 hours, 13 minutes, 57 seconds

Miles Traveled: Approximately 4,051,000 statute miles

Inclination: 51.6 degrees

Orbits of Earth: 154

Orbital Altitude: 173 nautical miles (199 statute miles)

Orbiter Weight at Landing: Approximately 221,664 pounds

Lift-off Weight: Approximately 4,514,231 pounds

Orbiter Weight at Lift-off: Approximately 227,974 pounds

Payload Weight Up: Approximately 22,707 pounds

Payload Weight Down: Approximately 19,390 pounds

Landing Touchdown: Approximately 2,084 feet beyond threshold

Landing Rollout: Approximately 8,848 feet

Landing Speed at Main Gear Touchdown: Approximately 211 knots (243 miles per hour)

Landed: Concrete runway 15 at Kennedy Space Center, Florida

Payloads: International Space Station (A.1); SPACEHAB double module; Integrated Vehicle Health Monitoring HEDS Technology Demonstration 2; Student-Tracked Atmospheric Research Satellite for Heuristic International Networking Equipment (STARSHINE); Shuttle Vibration Forces Experiment; MIRTS change-out; cargo transfer

Extravehicular Activity (EVA): EVA 1, Tammy Jernigan and Dan Barry, 7 hours, 55 minutes. During the EVA, Jernigan and Barry transferred and installed two cranes from the Shuttle's payload bay to locations on the outside of the station. They also installed two new portable foot restraints that will fit both American and Russian space boots, and attached three bags filled with tools and handrails that will be used during future assembly operations. Once those primary tasks were accomplished, Jernigan and Barry installed an insulating cover on a trunnion pin on the Unity module,

documented painted surfaces on both the Unity and Zarya modules, and inspected one of two early communications system antennas on the Unity. Other tasks completed during the spacewalk included moving foot restraints into PMA-1 (Primary Mating Adapter) and installing three bags containing tools for use during later flights. Throughout the spacewalk, Jernigan and Barry were assisted by their crew mates as Mission Specialist Ellen Ochoa operated the Shuttle's robot arm to maneuver Jernigan around Discovery's cargo bay, and Canadian Space Agency astronaut Julie Payette acted as "choreographer" of the spacewalk from Discovery's flight deck.

STS-93 Mission Facts — Columbia — July 23–27, 1999

Commander: Eileen M. Collins
Pilot: Jeffrey S. Ashby
Mission Specialist: Steven A. Hawley
Mission Specialist: Catherine G. Coleman
Mission Specialist: Michael Tognini, CNES
Mission Duration: 96 hours (4 days), 22 hours, 50 minutes, 22 seconds
Miles Traveled: Approximately 1.8 million statute miles
Inclination: 28.45 degrees
Orbits of Earth: 80
Orbital Altitude: 153 nautical miles (176 statute miles)
Orbiter Weight at Landing: Approximately 202,338 pounds
Lift-off Weight: Approximately 4,524,972 pounds
Orbiter Weight at Lift-off: Approximately 270,387 pounds
Payload Weight Up: Approximately 49,789 pounds
Payload Weight Down: Approximately 6,709 pounds
Landing Touchdown: Approximately 2,696 feet beyond threshold
Landing Rollout: Approximately 6,777 feet
Landing Speed at Main Gear Touchdown: Approximately 201 knots (231 miles per hour)
Landed: Concrete runway 33 at Kennedy Space Center, Florida
Payloads: Chandra X-Ray Observatory (CXO); Plant Growth Investigations in Microgravity 1; Southwest Ultraviolet Imaging System; Gelation of Sols: Applied Microgravity Research; Space Tissue Loss; Lightweight Flexible Solar Array Hinge; Cell

STS-93 Mission Facts (Cont)

Culture Module, Configuration C; Shuttle Amateur Radio Experiment II; Commercial Generic Bioprocessing Apparatus; Micro-Electro-Mechanical Systems; Biological Research in Canisters

STS-103 Mission Facts — Discovery — Dec. 19–27, 1999

Commander: Curtis L. Brown

Pilot: Scott J. Kelly

Mission Specialist: Jean-Francois Clervoy, European Space Agency

Mission Specialist: Steven L. Smith

Mission Specialist: C. Michael Foale

Mission Specialist: John M. Grunsfeld

Mission Specialist: Claude Nicollier, European Space Agency

Mission Duration: 168 hours (7 days), 23 hours, 10 minutes, 47 seconds

Miles Traveled: Approximately 3,267,000 statute miles

Inclination: 28.45 degrees

Orbits of Earth: 120

Orbital Altitude: 317 nautical miles (365 statute miles)

Orbiter Weight at Landing: 210,977

Lift-off Weight: Approximately 4,506,419 pounds

Orbiter Weight at Lift-off: Approximately 248,159 pounds

Payload Weight Up: Approximately 13,208 pounds

Payload Weight Down: Approximately 13,136 pounds

Landing Touchdown: Approximately 2,926 feet beyond threshold

Landing Rollout: Approximately 6,975 feet

Landing Speed at Main Gear Touchdown: Approximately 187 knots (215 miles per hour)

Landed: Concrete runway 33 at Kennedy Space Center, Florida

Payload: Hubble Space Telescope servicing mission 03-A (fine guidance sensor; gyroscopes; new advanced computer; new thermal blanket layers; S-band single-access transmitter; solid-state recorder; and voltage/temperature improvement kits)

STS-103 Mission Facts (Cont)

Extravehicular Activity (EVA): EVA 1, Steve Smith and John Grunsfeld, 8 hours, 15 minutes. During the EVA, Smith and Grunsfeld installed six new gyroscopes and six voltage/temperature improvement kits in the telescope. EVA 2, Mike Foale and Claude Nicollier, 8 hours, 10 minutes. During the EVA, they installed a new advanced computer, 20 times faster and with six times the memory of the previous machine, and replaced a 550-lb. fine guidance sensor, one of three on the telescope. EVA 3, Smith and Grunsfeld, 8 hours, 8 minutes. During the EVA, Smith and Grunsfeld replaced a failed radio transmitter and installed a new digital solid-state recorder that will provide more than 10 times the storage capacity of the old unit. They also applied new insulation on two equipment bay doors. Both the transmitter and the recorder checked out normally on early tests by telescope controllers. Total time servicing the Hubble: 93 hours, 13 minutes.

STS-99 Mission Facts — Endeavour — Feb. 11–22, 2000

Commander: Kevin R. Kregel
Pilot: Dom L. Gorie
Mission Specialist: Gerhard P.J. Thiele
Mission Specialist: Janet L. Kavandi
Mission Specialist: Janice Voss
Mission Specialist: Mamoru Mohri
Mission Duration: 264 hours (11 days), 5 hours, 38 minutes
Miles Traveled: Approximately 4 million statute miles
Inclination: 57 degrees
Orbits of Earth: 182
Orbital Altitude: 126 nautical miles (approximately 145 statute miles)
Orbiter Weight at Landing: 225,669 pounds
Lift-off Weight: Approximately 4,520,415 pounds
Orbiter Weight at Lift-off: Approximately 256,560 pounds
Payload Weight Up: Approximately 14.5 tons (29,000 pounds)
Payload Weight Down: Approximately 28,740 pounds
Landing Touchdown: Approximately 2,967 feet beyond threshold
Landing Rollout: Approximately 9,954 feet
Landing Speed at Main Gear Touchdown: Approximately 206 knots (237 miles per hour)
Landed: Concrete runway 33 at Kennedy Space Center, Fla.

STS-99 Mission Facts (Cont)

Payload: Shuttle Radar Topography Mission hardware (mast, antenna, and data recording, processing products)

STS-101/2A.2a Mission Facts — Atlantis — May 19–29, 2000

Commander: James D. Halsell
Pilot: Scott J. Horowitz
Mission Specialist: Mary Ellen Weber
Mission Specialist: Jeffrey N. Williams
Mission Specialist: James S. Voss
Mission Specialist: Susan J. Helms
Mission Specialist: Yuri V. Usachev
Mission Duration: 216 hours (9 days), 20 hours, 10 minutes
Miles Traveled: 4,076,241 statute miles
Inclination: 51.6 degrees
Orbits of Earth: 156
Orbital Altitude: 173 nautical miles (approximately 259 statute miles)
Orbiter Weight at Landing: 221,271 pounds
Lift-off Weight: 4,519,645 pounds
Orbiter Weight at Lift-off: 262,528 pounds
Payload Weight Up: 24,733 pounds
Payload Weight Down: 23,074 pounds
Landing Touchdown: Approximately 3,359 feet beyond threshold
Landing Rollout: Approximately 8,917 feet
Landing Speed at Main Gear Touchdown: Approximately 202 knots (232 miles per hour)
Landed: Concrete runway 15 at Kennedy Space Center, Fla.
Payload: BioTube precursor experiment; SPACEHAB; integrated cargo carrier; mission to America's remarkable schools; space experiment module 6; HTD 1403 micro wireless instrumentation system HEDS technology demonstration.
Extravehicular Activity (EVA): Only one EVA on this mission, performed by James S. Voss and Jeffrey N. Williams, 6 hours, 30 minutes. During the EVA, Voss and Williams made the last planned equipment changes prior to the arrival of the ISS's third element, Russia's service module Zvezda. They completed assembly of a Russian crane, tested the integrity of a U.S. crane, replaced a faulty communications antenna, installed handrails, and set up a camera cable.

STS-106/2A.2b Mission Facts — Atlantis — Sept. 8–20, 2000

Commander: Terrence Wilcutt

Pilot: Scott D. Altman

Mission Specialist: Edward T. Lu

Mission Specialist: Richard A. Mastracchio

Mission Specialist: Daniel C. Burbank

Mission Specialist: Yuri I. Malenchenko

Mission Specialist: Boris V. Morukov

Mission Duration: 283 hours (11 days), 19 hours, 11 minutes

Miles Traveled: 4.9 million

Inclination: 51.6 degrees

Orbits of Earth: 185

Orbital Altitude: 177 nautical miles (approximately 203 statute miles)

Orbiter Weight at Landing: 221,803 pounds

Lift-Off Weight: 4,519,178 pounds

Orbiter Weight at Lift-Off: 262,053 pounds

Payload Weight Up: 23,967 pounds

Payload Weight Down: 20,173 pounds

Landing Touchdown: Approximately 3,066 feet beyond threshold

Landing Rollout: Approximately 9,115 feet

Landing Speed at Main Gear Touchdown: Approximately 187 knots (215 miles per hour)

Landed: Concrete runway 15 at Kennedy Space Center, Fla.

Payload: Space Experiment Module 8; Getaway Special G-782, SPACEHAB Logistics Double Module (in cargo bay); Commercial Generic Bioprocessing Apparatus (in-cabin).

Extravehicular Activity (EVA): EVA 1, Mission Specialists Dr. Edward Lu and Col. Yuri Malenchenko, 6 hours, 14 minutes. This was the sixth space walk in support of the assembly of the ISS and the 50th in Shuttle history. During the EVA, the two made the grueling ascent to lay cable and install a boom for a navigation unit on the exterior of the ISS. They ventured 110 feet from the Shuttle cargo bay, the farthest distance any NASA spacewalker has ever ventured while tethered. They had to scale the Russian service module Zvezda to erect the boom for a compass and to install the cables between Zvezda and the other Russian module, Zarya.

STS-92 Mission Facts — Discovery — Oct. 11–24, 2000

Commander: Brian Duffy

Pilot: Pamela Ann Melroy

Mission Specialist: Koichi Wakata, National Space Development Agency of Japan

Mission Specialist: Peter J.K. (Jeff) Wisoff

STS-92 Mission Facts (Cont)

Mission Specialist: Leroy Chiao
Mission Specialist: William S. McArthur, Jr.
Mission Specialist: Michael E. Lopez-Alegria
Mission Duration: 288 hours (12 days), 21 hours, 43 minutes, 47 seconds
Miles Traveled: Approximately 5.3 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 203
Orbital Altitude: 173 nautical miles (approximately 259 statute miles)
Orbiter Weight at Landing: 204,455 pounds
Lift-Off Weight: Approximately 4,520,596 pounds
Orbiter Weight at Lift-Off: 253,807 pounds
Payload Weight Up: 28,009 pounds
Payload Weight Down: 6,304 pounds
Landing Touchdown: Approximately 2,771 feet beyond threshold
Landing Rollout: Approximately 9,087 feet
Landing Speed at Main Gear Touchdown: Approximately 205 knots (236 miles per hour)
Landed: Concrete runway 22 at Edwards Air Force Base, California
Payload: International Space Station (3A); Z1 truss; pressurized mating adapter 3 (PMA-3); five DTOs; cargo transfer.
Extravehicular Activity (EVA): EVA 1, Mission Specialists Leroy Chiao and William McArthur, 6 hours, 28 minutes. During EVA 1, Chiao and McArthur relocated the S-band antenna support assembly on the Z1 truss and connected Z1-to-Unity umbilicals. EVA 2, Mission Specialists Jeff Wisoff and Michael Lopez-Alegria, 7 hours, 7 minutes. During EVA 2, Koichi Wakata used the shuttle's robotic arm to grapple and install PMA-3 on Unity's nadir port. Wisoff and Lopez-Alegria connected cables between PMA-3 and Unity. EVA 3, Mission Specialists Chiao and McArthur, 6 hours, 48 minutes. During EVA 3, Chiao and McArthur installed two DC-to-DC converter unit heat pipes on the Z1 truss and relocated the Z1 keel pin assembly. EVA 4, Mission Specialists Wisoff and Lopez-Alegria, 6 hours, 56 minutes. During EVA 4, Wisoff and Lopez-Alegria removed a grapple fixture on the Z1 truss. Wisoff and Lopez-Alegria also performed a safety protocol test, a flight evaluation of simplified aid for EVA rescue (SAFER).

100th Space Shuttle mission

STS-97 Mission Facts — Endeavour — Nov. 30–Dec. 11, 2000

Commander: Brent W. Jett Jr.

Pilot: Michael J. Bloomfield

Mission Specialist: Marc Garneau, Canadian Space Agency

Mission Specialist: Joseph R. Tanner

Mission Specialist: Carlos I. Noriega

Mission Duration: 240 hours (10 days), 19 hours, 58 minutes

Miles Traveled: Approximately 4.47 million statute miles

Inclination: 51.6 degrees

Orbits of Earth: 170

Orbital Altitude: 173 nautical miles (approximately 259 statute miles)

Orbital ISS Rendezvous Altitude: 205 nautical miles (approximately 307 statute miles)

Orbiter Weight at Landing: 197,377 pounds

Lift-Off Weight: 4,524,795 pounds

Orbiter Weight at Lift-Off: 266,570 pounds

Payload Weight Up: 37,496 pounds

Payload Weight Down: 1,920 pounds

Landing Touchdown: Approximately 2,476 feet beyond threshold

Landing Rollout: Approximately 7,961 feet

Landing Speed at Main Gear Touchdown: Approximately 195 knots (224 miles per hour)

Landed: Concrete runway 15 at Kennedy Space Center, Fla.

Payload: International Space Station (4A); P6 photovoltaic array assembly; integrated equipment assembly; five DTOs, one DSO, and two HTDs.

Extravehicular Activity (EVA): EVA 1, Mission Specialists Joseph Tanner and Carlos Noriega, 7 hours, 33 minutes. During EVA 1, Tanner and Noriega attached the P6 integrated truss structure to the Z1 truss, prepared the solar arrays for deployment, and prepared the radiator for power system deployment. EVA 2, Tanner and Noriega, 6 hours, 37 minutes. During EVA 2, Tanner and Noriega configured the ISS for use of the power from the P6, positioned the S-band for use by the space station, and prepared the ISS for the arrival of the U.S. Laboratory on mission ISS-5A. EVA 3, Tanner and Noriega, 5 hours, 10 minutes. During EVA 3, Tanner and Noriega performed repair work to increase tension in the starboard solar array blankets and performed get-ahead tasks that were planned for future space station assembly missions.

STS-98 Mission Facts — Atlantis — Feb. 7–20, 2001

Commander: Kenneth D. Cockrell
Pilot: Mark L. Polansky
Mission Specialist: Marsha Ivins
Mission Specialist: Thomas D. Jones
Mission Specialist: Robert L. Curbeam Jr.
Mission Duration: 288 hours (12 days), 21 hours, 20 minutes
Miles Traveled: Approximately 5.3 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 203
Orbital Altitude: 177 nautical miles
Orbital ISS Rendezvous Altitude: Approximately 200 nautical miles
Orbiter Weight at Landing: 198,849 pounds
Lift-Off Weight: Approximately 4.5 million pounds
Orbiter Weight at Lift-Off: 264,127 pounds
Payload Weight Up: 33,286 pounds
Payload Weight Down: 2,673 pounds
Landing Touchdown: Approximately 2,095 feet beyond threshold
Landing Rollout: Approximately 7,964 feet
Landing Speed at Main Gear Touchdown: Approximately 198 knots (228 miles per hour)
Landed: Concrete runway 22 at Edwards Air Force Base, Calif.
Payload: ISS Assembly Flight 5A, U.S. Laboratory Module "Destiny"
Extravehicular Activity (EVAs): EVA 1, mission specialists Bob Curbeam and Tom Jones, 7 hours, 34 minutes, Curbeam and Jones installed and hooked up Destiny to ISS's Unity module. EVA 2, Curbeam and Jones, 6 hours, 50 minutes. Curbeam and Jones attached a station docking adapter to the forward end of Destiny to establish a new docking port for future Shuttle assembly flights. EVA 3, Curbeam and Jones, 5 hours, 25 minutes, the 100th spacewalk in U.S. space program history. Curbeam and Jones attached a spare communications antenna on the exterior of the ISS and inspected the exterior of the ISS and the U.S. solar arrays.

STS-102 Mission Facts — Discovery — March 8–21, 2001

Commander: James D. Weatherbee
Pilot: James M. Kelly
Mission Specialist: Andrew S.W. Thomas
Mission Specialist: Paul W. Richards
ISS Crew Member: Yury V. Usachev—up only
ISS Crew Member: Susan J. Helms—up only

STS-102 Mission Facts (Cont)

ISS Crew Member: James S. Voss—up only
ISS Crew Member: William M. Shepherd—down only
ISS Crew Member: Sergei K. Krikalev—down only
ISS Crew Member: Yuri P. Gidzenko—down only
Mission Duration: 288 hours (12 days), 19 hours, 49 minutes
Miles Traveled: Approximately 5.4 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 202
Orbital Altitude: 122 nautical miles (approximately 140 statute miles)
Orbital ISS Rendezvous Altitude: 205 nautical miles
Orbiter Weight at Landing: 217,771 pounds
Lift-Off Weight: Approximately 4.5 million pounds
Orbiter Weight at Lift-Off: 264,797 pounds
Payload Weight Up: 28,739 pounds
Payload Weight Down: 20,389 pounds
Landing Touchdown: Approximately 2,952 feet beyond threshold
Landing Rollout: Approximately 11,409 feet
Landing Speed at Main Gear Touchdown: Approximately 199 knots (229 miles per hour)
Landed: Concrete runway 15 at Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 5A.1, Leonardo Multi-Purpose Logistics Module
Extravehicular Activity (EVAs): EVA 1, Susan Helms and Jim Voss, 8 hours, 56 minutes. Helms and Voss prepared one of ISS's berthing ports for the Leonardo transfer module. EVA 2, Paul Richards and Andy Thomas, 6 hours, 30 minutes. Richards and Thomas continued work to outfit the station and prepare for delivery of its own robotic arm on the next mission.

STS-100 Mission Facts — Endeavour — April 19–May 1, 2001

Commander: Kent V. Rominger
Pilot: Jeffrey S. Ashby
Mission Specialist: Chris A. Hadfield, Canadian Space Agency
Mission Specialist: John L. Phillips
Mission Specialist: Scott E. Parazynski
Mission Specialist: Umberto Guidoni, European Space Agency
Mission Specialist: Yuri Valentinovich Lonchakov, Russian Air Force
Mission Duration: 264 hours (11 days), 21 hours, 30 minutes
Miles Traveled: Approximately 4.9 million statute miles
Inclination: 51.6 degrees

STS-100 Mission Facts (Cont)

Orbits of Earth: 186
Orbital Altitude: 173 nautical miles (approximately 259 statute miles)
Orbital ISS Rendezvous Altitude: 240 nautical miles
Orbiter Weight at Landing: 220,125 pounds
Lift-Off Weight: 4,522,246 pounds
Orbiter Weight at Lift-Off: 265,268 pounds
Payload Weight Up: 29,472 pounds
Payload Weight Down: 20,346 pounds
Landing Touchdown: Approximately 2,219 feet beyond threshold
Landing Rollout: Approximately 7,992 feet
Landing Speed at Main Gear Touchdown: Approximately 207 knots (238 miles per hour)
Landed: Concrete runway 22 at Edwards Air Force Base, Calif.
Payload: ISS Assembly Flight 6A, Raffaello Multi-Purpose Logistics Module, Space Station Remote Manipulator System (SSRMS), also known as Canadarm2, UHF antenna
Extravehicular Activity (EVAs) conducted by Scott Parazynski and Chris Hadfield. EVA 1, 7 hours, 10 minutes, Parazynski and Hadfield installed and deployed the UHF antenna on Destiny and began installation of Canadarm2. EVA 2, 7 hours, 40 minutes, Parazynski and Hadfield completed power and data connections on Canadarm2.

STS-104 Mission Facts — Atlantis — July 12–24, 2001

Commander: Steven W. Lindsey
Pilot: Charles O. Hobaugh
Mission Specialist: Michael L. Gernhardt
Mission Specialist: James F. Reilly
Mission Specialist: Janet L. Kavandi
Mission Duration: 288 hours (12 days), 18 hours, 35 minutes
Miles Traveled: Approximately 5.3 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 200
Orbital Insertion Altitude: 122 nautical miles
Orbital ISS Rendezvous Altitude: 240 nautical miles
Orbiter Weight at Landing: 206,902 pounds
Lift-Off Weight: 4,520,159 pounds
Orbiter Weight at Lift-Off: 262,952 pounds
Payload Weight Up: 26,424 pounds
Payload Weight Down: 7,268 pounds
Landing Touchdown: Approximately 2,273 feet beyond threshold

STS-104 Mission Facts (Cont)

Landing Rollout: Approximately 10,854 feet
Landing Speed at Main Gear Touchdown: Approximately 198 knots (228 miles per hour)
Landed: Concrete runway 15 at Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 7A, Joint Airlock and High-Pressure Gas Tanks; first flight of Block II main engine high-pressure fuel turbopump
Extravehicular Activity (EVAs) conducted by Michael Gernhardt and James Reilly. EVA 1, 5 hours, 59 minutes, Gernhardt and Reilly assisted space station robot arm operator Susan Helms with installation of the joint airlock onto the station.
EVA 2, 6 hours, 29 minutes, Gernhardt and Reilly installed three high-pressure gas tanks (two oxygen and one nitrogen) onto the joint airlock. EVA 3, 4 hours, 2 minutes, Gernhardt and Reilly, conducting first spacewalk from new joint airlock, installed fourth high-pressure gas tank (nitrogen) onto the joint airlock, plus handholds and communications cables.

STS-105 Mission Facts — Discovery — August 10–22, 2001

Commander: Scott J. Horowitz
Pilot: Rick Sturckow
Mission Specialist: Daniel T. Barry
Mission Specialist: Patrick G. Forrester
ISS Crew Member: Frank L. Culbertson Jr.—up only
ISS Crew Member: Vladimir N. Dezhurov, Russian Space Agency—up only
ISS Crew Member: Mikhail Turin, Russian Space Agency—up only
ISS Crew Member: Yury V. Usachev, Russian Space Agency—down only
ISS Crew Member: James S. Voss—down only
ISS Crew Member: Susan J. Helms—down only
Mission Duration: 264 hours (11 days), 21 hours, 13 minutes
Miles Traveled: Approximately 4.3 million statute miles
Inclination: 51.6 degrees
Orbits of Earth: 186
Orbital Insertion Altitude: 122 nautical miles
Orbital ISS Rendezvous Altitude: 240 nautical miles
Lift-Off Weight: 4,518,170 pounds
Orbiter Weight at Lift-Off: 262,477 pounds
Payload Weight Up: 29,305 pounds
Landing Touchdown: Approximately 1,595 feet beyond threshold
Landing Rollout: Approximately 10,048 feet
Landing Speed at Main Gear Touchdown: Approximately 202 knots (232 miles per hour)

STS-105 Mission Facts (Cont)

Orbiter Weight at Landing: 222,250 pounds
Payload Weight Down: 23,456 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 7A.1, Leonardo Multi-Purpose Logistics Module (MPLM); second ISS crew exchange
Extravehicular Activity (EVAs) conducted by Daniel Barry and Patrick Forrester. EVA 1, 6 hours, 16 minutes, Barry and Forrester installed an early ammonia servicer onto the P6 truss and installed the Materials International Space Station Experiment onto the joint airlock. EVA 2, 5 hours, 29 minutes, Barry and Forrester installed handrails and heater cables onto the U.S. Laboratory. The cables may be used on mission STS-110 to power heaters on the S0 truss segment.

STS-108 Mission Facts — Endeavour — December 5–17, 2001

Commander: Dominic L. Gorie
Pilot: Mark E. Kelly
Mission Specialist: Linda M. Godwin
Mission Specialist: Daniel M. Tani
ISS Crew Member: Yuri I. Onufrienko, Russian Space Agency—up only
ISS Crew Member: Daniel W. Bursch—up only
ISS Crew Member: Carl E. Walz—up only
ISS Crew Member: Frank L. Culbertson—down only
ISS Crew Member: Vladimir N. Dezhurov, Russian Space Agency—down only
ISS Crew Member: Mikhail Turin, Russian Space Agency—down only
Mission Duration: 264 hours (11 days), 19 hours, 37 minutes
Miles Traveled: Approximately 4.8 million statute miles
Orbits of Earth: 185
Orbital Insertion Altitude: 122 nautical miles
Inclination: 51.6 degrees
Orbital ISS Rendezvous Altitude: 205 nautical miles
Lift-off Weight: 4,519,872 pounds
Payload Weight Up: 31,393 pounds
Orbiter Weight at Landing: 225,169 pounds
Payload Weight Down: 28,826 pounds
Landed: Concrete runway 15 at Kennedy Space Center, Fla.
Payload: ISS Assembly Flight UF-1, Raffaello Multi-Purpose Logistics Module, Multiple Application Customized Hitchhiker-1, STARSHINE 2, "Flags for Heroes and Families" in honor of the victims of 9-11-01; third ISS crew exchange

STS-108 Mission Facts (Cont)

Extravehicular Activity (EVA) conducted by Linda Godwin and Daniel Tani; 4 hours, 12 minutes; Godwin and Tani installed insulation on mechanisms that rotate the International Space Station's main solar arrays. This completed a record year for spacewalks, with 12 spacewalks originating from the space shuttle and six from the space station.

STS-109 Mission Facts — Columbia — March 1–12, 2002

Commander: Scott D. Altman
Pilot: Duane G. Carey
Payload Commander: John M. Grunsfeld
Mission Specialist: Nancy J. Currie
Mission Specialist: James H. Newman
Mission Specialist: Richard M. Linnehan
Mission Specialist: Michael J. Massimino
Mission Duration: 240 hours (10 days), 22 hours, 11 minutes
Miles Traveled: Approximately 3.9 million statute miles
Orbits of Earth: 165
Inclination: 28.5 degrees
Orbital Altitude: 308 nautical miles
Lift-Off Weight: 4,515,646 pounds
Orbiter Weight at Lift-Off: 260,665 pounds
Payload Weight Up: 27,594 pounds
Orbiter Weight at Landing: 258,788 pounds
Payload Weight Down: 25,717 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Fla.
Payload: Hubble Space Telescope Servicing Mission 3B: Advanced Camera for Surveys, new rigid solar arrays (SA3), new power control unit (PCU), new cryocooler for Near-Infrared Camera and Multi-Object Spectrometer (NICMOS), reaction wheel assembly (RWA1)
Extravehicular Activity (EVA) conducted by team of John Grunsfeld and Richard Linnehan and team of James Newman and Michael Massimino. EVA 1, 7 hours, 1 minute, Grunsfeld and Linnehan replaced the starboard solar array; EVA 2, 7 hours, 16 minutes, Newman and Massimino replaced the port solar array and reaction wheel assembly; EVA 3, 6 hours, 48 minutes, Grunsfeld and Linnehan replaced the power control unit; EVA 4, 7 hours, 30 minutes, Newman and Massimino replaced the Faint Object Camera with the Advanced Camera for Surveys; EVA 5, 7 hours, 20 minutes, Grunsfeld and Linnehan installed a new cooling system for the Near-Infrared Camera and Multi-Object Spectrometer.

STS-110 Mission Facts — Atlantis — April 8–19, 2002

Commander: Michael J. Bloomfield
Pilot: Stephen N. Frick
Mission Specialist: Jerry L. Ross
Mission Specialist: Steven L. Smith
Mission Specialist: Ellen Ochoa
Mission Specialist: Lee M.E. Morin
Mission Specialist: Rex J. Walheim
Mission Duration: 240 hours (10 days), 19 hours, 42 minutes
Miles Traveled: Approximately 4.5 million statute miles
Orbits of Earth: 171
Inclination: 51.6 degrees
Orbital Altitude: 247 nautical miles
Lift-Off Weight: 4,520,940 pounds
Orbiter Weight at Lift-Off: 257,079 pounds
Payload Weight Up: 28,379 pounds
Orbiter Weight at Landing: 200,657 pounds
Payload Weight Down: 1,493 pounds
Landed: Concrete runway 33 at Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 8A; Starboard-zero (S0) Central Integrated Truss Structure; Mobile Transporter, which will be attached to the Mobile Base System during STS-111 to create the first "railroad in space"; first flight of three Block II main engines
Extravehicular Activity (EVA) conducted by team of Steven Smith and Rex Walheim and team of Jerry Ross and Lee Morin. EVA 1, 7 hours, 48 minutes; after the S0 Truss was lifted by the Canadarm2 from Atlantis' cargo bay and installed on the U.S. Laboratory, Smith and Walheim made power and data connections and bolted two forward struts. EVA 2, 7 hours, 30 minutes; Ross and Morin continued power and data connections between the S0 and ISS and bolted two aft struts. EVA 3, 6 hours, 27 minutes; Smith and Walheim installed power connections for Canadarm2 to use when on the truss. EVA 4, 6 hours, 25 minutes; Ross and Morin installed a beam called the Airlock Spur between the Quest airlock and the S0 and installed handrails on the S0. Ross set new record for most spacewalks (nine), as well as a new record for most space shuttle missions (seven).

STS-111 Mission Facts — Endeavour — June 5–19, 2002

Commander: Kenneth D. Cockrell

Pilot: Paul S. Lockhart

Mission Specialist: Franklin R. Chang-Diaz

Mission Specialist: Philippe Perrin, Centre National D'Etudes Spatiales (CNES, French Space Agency)

ISS Crew Member: Valery G. Korzun, Russian Space Agency—up only

ISS Crew Member: Peggy A. Whitson—up only

ISS Crew Member: Sergei Y. Treschev, Russian Space Agency—up only

ISS Crew Member: Yuri I. Onufrienko, Russian Space Agency—down only

ISS Crew Member: Carl E. Walz—down only

ISS Crew Member: Daniel W. Bursch—down only

Mission Duration: 312 hours (13 days), 20 hours, 35 minutes

Miles Traveled: Approximately 5.78 million statute miles

Orbits of Earth: 217

Inclination: 51.6 degrees

Orbital ISS Altitude: Approximately 240 nautical miles

Lift-Off Weight: 4,518,239 pounds

Orbiter Weight at Lift-Off: 256,884 pounds

Payload Weight Up: 29,810 pounds

Orbiter Weight at Landing: 219,103 pounds

Payload Weight Down: 22,099 pounds

Landed: Concrete runway 22 at Edwards Air Force Base, Calif.

Payload: ISS Utilization Flight UF-2; Leonardo Multi-Purpose Logistics Module carrying experiment racks, equipment, and supplies; Mobile Base System (MBS) installed on Mobile Transporter (MT) to complete Mobile Servicing System; replacement of Canadarm2 wrist roll joint; and fourth ISS crew exchange. ISS crew members Walz and Bursch set new record for longest U.S. space flight (196 days), breaking the previous record of 188 days in space held by Shannon Lucid aboard the Russian space station Mir. Walz now also holds the U.S. record for the most cumulative time in space with 231 days.

Extravehicular Activity (EVA) conducted by team of Franklin Chang-Diaz and Philippe Perrin. EVA 1, 7 hours, 14 minutes; Chang-Diaz and Perrin attached a power and data grapple fixture onto the P6 truss, setting the stage for the future relocation of the P6, and removed thermal blankets to prepare MBS for installation. Whitson and Walz used Canadarm2 to lift the MBS out of the payload bay. EVA 2, 5 hours; the focus was on outfitting and permanently attaching the MBS to the MT. Chang-Diaz and Perrin attached power, data, and video cables from the station to the MBS. EVA 3, 7 hours, 17 minutes; Chang-Diaz and Perrin replaced Canadarm2's wrist roll joint.

STS-112 Mission Facts — Atlantis — October 7–18, 2002

Commander: Jeffrey S. Ashby

Pilot: Pamela A. Melroy

Mission Specialist: David A. Wolf

Mission Specialist: Piers J. Sellers

Mission Specialist: Sandra H. Magnus

Mission Specialist: Fyodor N. Yurchikhin, Russian Space Agency

Launched: 3:45:51 p.m. EDT, launch pad 39B, Kennedy Space Center, Fla.

Mission Duration: 240 hours (10 days), 19 hours, 58 minutes

Miles Traveled: Approximately 4.5 million statute miles

Orbits of Earth: 170

Inclination: 51.6 degrees

Orbital Altitude: 210 nautical miles

Lift-Off Weight: 4,521,314 pounds

Orbiter Weight at Lift-Off: 265,812 pounds

Payload Weight Up: 29,502 pounds

Orbiter Weight at Landing: 201,299 pounds

Payload Weight Down: 1,733 pounds

Landed: 11:44:35 a.m. EDT, concrete runway 33, Kennedy Space Center, Fla.

Payload: ISS Assembly Flight 9A; 14-ton Starboard-One (S1) Truss Structure preintegrated with a standard Tracking and Data Relay Satellite System (TDRSS) transponder, Audio Communication System (ACS) baseband signal processor, S-band communication equipment, Thermal Radiator Rotary Joint (TRRJ), three External Active Thermal Control System (EATCS) radiators, Direct Current (DC)-to-DC Converter Unit (DDCU), Remote Power Controller Module (RPCM), and Crew Equipment Translation Aid (CETA) cart; secondary payloads of Spatial Heterodyne Imager for Mesospheric Radicals (SHIMMER) and Ram Burn Observation (RAMBO); three DTOs; eight DSOs; first use of Shuttle Observation Camera System mounted to external tank

Extravehicular Activity (EVA) conducted by team of David Wolf and Piers Sellers from joint airlock "Quest." EVA 1, 7 hours, 1 minute; after the S1 Truss was lifted from Atlantis' cargo bay by the Canadarm2, operated by ISS crew member Peggy Whitson, and attached to the S0 Truss, Wolf and Sellers attached power, data, and fluid lines between the S1 and S0, deployed the station's second S-band communications system, and installed the first of two external camera systems. EVA 2, 6 hours, 4 minutes; Wolf and Sellers set up a second camera

STS-112 Mission Facts (Cont)

system, released restraints on the CETA cart, and attached ammonia tank assembly cables. EVA 3, 6 hours, 36 minutes; Wolf and Sellers removed and replaced the Interface Umbilical Assembly on the station's Mobile Transporter and installed jumpers and spool positioning devices on the ammonia lines between the S1 and S0 Trusses.

STS-113 Mission Facts — Endeavour — Nov. 23–Dec. 7, 2002

Commander: James D. Wetherbee
Pilot: Paul S. Lockhart
Mission Specialist: Michael E. Lopez-Alegria
Mission Specialist: John B. Herrington
ISS Crew Member: Kenneth D. Bowersox—up only
ISS Crew Member: Nikolai M. Budarin, Russian Space Agency—up only
ISS Crew Member: Donald R. Pettit—up only
ISS Crew Member: Valeri G. Korzun, Russian Space Agency—down only
ISS Crew Member: Peggy A. Whitson—down only
ISS Crew Member: Sergei Y. Treschev, Russian Space Agency—down only
Launched: 7:49:47 p.m. EST, launch pad 39A, Kennedy Space Center, Fla.
Mission Duration: 312 hours (13 days), 18 hours, 47 minutes
Miles Traveled: Approximately 5.74 million statute miles
Orbits of Earth: 215
Inclination: 51.6 degrees
Orbital Altitude: 215 nautical miles
Lift-Off Weight: 4,521,249 pounds
Orbiter Weight at Lift-Off: 265,974 pounds
Payload Weight Up: 30,217 pounds
Orbiter Weight at Landing: 201,668 pounds
Payload Weight Down: 2,268 pounds
Landed: 2:37:12 p.m. EST, concrete runway 33, Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 11A; 14-ton Port-One (P1) Truss Structure preintegrated with Ultra-high Frequency (UHF) communication equipment, Thermal Radiator Rotary Joint (TRRJ), three External Active Thermal Control System (EATCS) radiators, Direct Current (DC)-to-DC Converter Unit (DDCU), Remote Power Controller Module (RPCM), Nitrogen Tank Assembly (NTA), Ammonia Tank Assembly (ATA), and Pump Module Assembly (PMA); second Crew and Equipment Translation Aid (CETA) cart that can be manually operated along the Mobile Transporter rail line; Micro-Electromechanical System (MEMS)-Based Pico Satellite (PICOSAT) Inspector (MEPSI); one DTO; eight DSOs; and fifth ISS crew exchange.

STS-113 Mission Facts (Cont)

Extravehicular Activity (EVA) conducted by team of Michael Lopez-Alegria and John Herrington from joint airlock "Quest." ISS robot arm operators: Peggy Whitson, Ken Bowersox, and Don Pettit. Space Shuttle robot arm operator: Jim Wetherbee. EVA 1, 6 hours, 45 minutes; after the P1 was attached to the station, Lopez-Alegria and Herrington started installing connections between the P1 and the S0 truss. They installed onto the Unity node the wireless video system external transceiver assembly, which will be used to support spacewalkers' helmet cameras. Herrington released launch restraints on the CETA cart. EVA 2, 6 hours, 10 minutes; Lopez-Alegria and Herrington installed another wireless video system external transceiver assembly onto the P1 and relocated the CETA cart from the P1 to the S1 truss, which will allow the mobile transporter to move along the P1 to assist in future assembly missions. EVA 3, 7 hours, 0 minutes; Lopez-Alegria and Herrington installed additional Spool Positioning Devices, reconfigured electrical har-nesses, and attached ammonia tank assembly lines.

STS-107 Mission Facts — Columbia — Jan. 16–Feb. 1, 2003

Commander: Rick D. Husband
Pilot: William C. McCool
Payload Commander: Michael P. Anderson
Mission Specialist: Kalpana Chawla
Mission Specialist: David M. Brown
Mission Specialist: Laurel B. Clark
Payload Specialist: Ilan Ramon, Israel
Launched: 10:39:00 a.m. EST, launch pad 39A, Kennedy Space Center, Fla.
Mission Duration: 360 hours (15 days), 22 hours, 21 minutes
Miles Traveled: Approximately 7.65 million statute miles
Orbits of Earth: 255
Inclination: 39 degrees
Orbital Altitude: 150 nautical miles
Lift-Off Weight: 4,525,842 pounds
Orbiter Weight at Lift-Off: 265,226 pounds
Payload Weight Up: 24,365 pounds
Payload: First flight of SPACEHAB as the SPACEHAB Research Double Module (SHRDM); Fast Reaction Experiments Enabling Science, Technology, Applications and Research (FREESTAR); first Extended Duration Orbiter (EDO) mission since STS-90. Mission dedicated to research in physical, life, and space sciences, conducted in approximately 80 experiments.
Loss of vehicle and crew during reentry, 9:00 a.m. EST

STS-114 Mission Facts — Discovery — July 26–Aug. 9, 2005

Commander: Eileen M. Collins

Pilot: James M. Kelly

Mission Specialist: Soichi Noguchi, National Space Development Agency of Japan (JAXA)

Mission Specialist: Stephen K. Robinson

Mission Specialist: Andrew S.W. Thomas

Mission Specialist: Wendy B. Lawrence

Mission Specialist: Charles J. Camarda

Launched: 10:39:00 a.m. EDT, launch pad 39B, Kennedy Space Center, Fla.

Mission Duration: 312 hours (13 days), 21 hours, 33 minutes

Miles Traveled: Approximately 5.8 million statute miles

Orbits of Earth: 219

Inclination: 51.6 degrees

Orbital Altitude: 122 nautical miles

Orbital ISS Rendezvous Altitude: Approximately 240 nautical miles

Lift-Off Weight: 4,522,992 pounds

Orbiter Weight at Lift-Off: 267,825 pounds

Payload Weight Up: 24,365 pounds

Orbiter Weight at Landing: 226,885 pounds

Payload Weight Down: 19,420 pounds

Landed: 5:12:36 a.m. PDT, concrete runway 22, Edwards Air Force Base, Calif.

Payload: ISS Assembly Flight LF1; first of two Return-to-Flight missions; Raffaello Multi-Purpose Logistics Module; test of orbiter boom sensor system (OBSS); test and evaluation of thermal protection system (TPS) repair techniques; replaced one ISS control gyroscope and restored power to a second gyroscope; installed work platform on ISS for future construction

Highlight: Before docking with the ISS, Collins performed the first Rendezvous Pitch Maneuver approximately 600 feet below the station. The motion flipped the shuttle end over end at 3/4 degree per second, allowing ISS crew members to photograph the underside of Discovery and its heat-resistant tiles in detail.

STS-114 Mission Facts (Cont)

Extravehicular Activity (EVA) conducted by team of Stephen Robinson and Soichi Noguchi. EVA 1, 6 hours, 50 minutes; Robinson and Noguchi worked in Discovery's cargo bay with tiles and reinforced carbon-carbon intentionally damaged on the ground and brought into space to conduct tile repair and adhesive experiments. In addition, they installed a base and cabling for a stowage platform and rerouted power to Control Moment Gyroscope 2. EVA 2, 7 hours, 14 minutes; Robinson and Noguchi removed the failed Control Moment Gyroscope 1 and installed its replacement. EVA 3, 6 hours, 1 minute; Attached to Canadarm2, Robinson was moved to Discovery's underside, where he pulled two protruding gap fillers from between thermal protection tiles. Robinson and Noguchi also installed an external stowage platform outside the ISS Quest airlock to house spare parts, and Noguchi installed a fifth Materials International Space Station Experiment (MISSE).

STS-121 Mission Facts — Discovery — July 4–17, 2006

Commander: Steven W. Lindsey
Pilot: Mark E. Kelly
Mission Specialist: Piers J. Sellers
Mission Specialist: Michael E. Fossum
Mission Specialist: Lisa M. Nowak
Mission Specialist: Stephanie D. Wilson
ISS Crew Member: Thomas Reiter, European Space Agency—up only
Launched: 2:38 p.m. EDT, launch pad 39B, Kennedy Space Center, Fla.
Mission Duration: 288 hours (12 days), 18 hours, 38 minutes
Miles Traveled: Approximately 5.3 million statute miles
Orbits of Earth: 202
Inclination: 51.6 degrees
Orbital Altitude: 122 nautical miles
Orbital ISS Rendezvous Altitude: Approximately 185 nautical miles
Lift-Off Weight: 4,523,850 pounds
Orbiter Weight at Lift-Off: 267,001 pounds
Payload Weight Up: 29,280 pounds
Orbiter Weight at Landing: 225,715 pounds
Payload Weight Down: 24,508 pounds
Landed: 9:14 a.m. EDT, concrete runway 15, Kennedy Space Center, Fla.

STS-121 Mission Facts (Cont)

Payload: ISS Assembly Flight ULF1.1; second Return-to-Flight mission; Leonardo Multi-Purpose Logistics Module carrying the Minus Eighty-Degrees Centigrade Laboratory Freezer for ISS (MELFI); Integrated Cargo Carrier (ICC); Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC)

Highlight: Before docking with the ISS, Lindsey performed a 360-degree backflip approximately 600 feet below the station, allowing ISS crew members to photograph the underside of Discovery and its heat-resistant tiles in detail.

Extravehicular Activity (EVA) conducted by team of Piers Sellers and Michael Fossum. EVA 1, 7 hours, 31 minutes; Sellers and Fossum installed a blade blocker in the zenith interface umbilical assembly to protect the power, data, and video cable, then rerouted the cable through the IUA so the mobile transporter rail car could be moved into position on the truss. In addition, they tested the capability of the space shuttle's robotic arm and its 50-foot extension—the orbiter boom sensor system—to act as a platform for spacewalkers making repairs. EVA 2, 6 hours, 47 minutes; Sellers and Fossum replaced the nadir-side trailing umbilical system (TUS) to restore the mobile transporter rail car to full operation and delivered a spare pump module for the ISS cooling system. EVA 3, 7 hours, 11 minutes; Sellers and Fossum tested techniques to inspect and repair damage to an orbiter's heat shield, including test of a repair material known as NOAX (non-oxide adhesive experimental), a pre-ceramic polymer sealant containing carbon-silicon carbide powder.

STS-115 Mission Facts — Atlantis — Sept. 9–21, 2006

Commander: Brent W. Jett

Pilot: Christopher J. Ferguson

Mission Specialist: Joseph R. Tanner

Mission Specialist: Daniel C. Burbank

Mission Specialist: Steven G. MacLean, Canadian Space Agency (CSA)

Mission Specialist: Heidemarie M. Stefanyshyn-Piper

Launched: 11:15 a.m. EDT, launch pad 39B, Kennedy Space Center, Fla.

Mission Duration: 264 hours (11 days), 19 hours, 6 minutes

Miles Traveled: Approximately 4.9 million statute miles

Orbits of Earth: 187

Inclination: 51.6 degrees

Orbital Altitude: 122 nautical miles

Orbital ISS Rendezvous Altitude: Approximately 185 nautical miles

STS-115 Mission Facts (Cont)

Lift-Off Weight: 4,526,580 pounds
Orbiter Weight at Lift-Off: 270,612 pounds
Payload Weight Up: 35,758 pounds
Orbiter Weight at Landing: 199,679 pounds
Payload Weight Down: 978 pounds
Landed: 6:21 a.m. EDT, concrete runway 33, Kennedy Space Center, Fla.
Payload: ISS Assembly Flight 12A, ITS P3 and P4, second port truss segment, second set of solar arrays and batteries. This addition added 45 feet to the ISS and increased the wingspan to more than 240 feet. The solar arrays will double power to the ISS when brought online during mission STS-116.
Extravehicular Activity (EVA) conducted by team of Heidemarie M. Stefanyshyn-Piper and Joe Tanner and team of Dan Burbank and Steve MacLean. EVA 1, 6 hours, 26 minutes; Piper and Tanner connected power cables on the truss and released the launch restraints on the solar array blanket box, beta gimbal assembly, and solar array wings. They also configured the solar alpha rotary joint (SARJ), an automobile-sized joint that allows the station's solar arrays to turn and point toward the Sun. EVA 2, 7 hours, 11 minutes; Burbank and MacLean devoted the spacewalk to the final tasks required for activation of the SARJ. EVA 3, 6 hours, 42 minutes; Piper and Tanner installed bolt retainers on the P6 beta gimbal assembly, which helps to orient the pitch of the solar array wings, and retrieved the Materials on the International Space Station Experiment 5.
Of Note: The shuttle critical systems, including its heat shield, were inspected three times during the mission using the orbiter boom sensor system, the 50-foot-long extension for the shuttle's robotic arm. In addition, a new procedure called a "camp out" was implemented in which astronauts slept in the Quest airlock prior to their spacewalks. The process shortens the "prebreathe" time during which nitrogen is purged from the astronauts' systems and air pressure is lowered to 10.2 psi so the spacewalkers avoid the condition known as the bends. On each of the three spacewalks, the astronauts were able to perform more than the number of scheduled activities.

UPCOMING SPACE SHUTTLE MISSIONS THROUGH JUNE 2007

STS-116 Flight Crew

Commander: Mark L. Polansky (second flight)
Pilot: William A. Oefelein (first flight)
Mission Specialist: Robert L. Curbeam Jr. (third flight)
Mission Specialist: Joan E. Higginbotham (first flight)
Mission Specialist: Nicholas J.M. Patrick (first flight)
Mission Specialist: Christer Fuglesang, European Space Agency (ESA) (first flight)
Payload: ISS Assembly Flight 12A.1; ITS P5, third port truss segment; SPACEHAB single cargo module; Integrated Cargo Carrier (ICC)
Projected launch date is December 2006, with Discovery (OV-103) in its 33rd flight

STS-117 Flight Crew

Commander: Frederick W. Sturckow (third flight)
Pilot: Lee J. Archambault (first flight)
Mission Specialist: James F. Reilly II (third flight)
Mission Specialist: Steven R. Swanson (first flight)
Mission Specialist: Patrick G. Forrester (second flight)
Mission Specialist: John D. Olivas (first flight)
Payload: ISS Assembly Flight 13A; ITS S3 and S4, second starboard truss segment; third set of solar arrays and batteries
Projected launch date is March 2007, with Atlantis (OV-104) in its 28th flight

STS-118 Flight Crew

Commander: Scott J. Kelly (second flight)
Pilot: Charles O. Hobaugh (second flight)
Mission Specialist: Dafydd (Dave) R. Williams (second flight)
Mission Specialist: Barbara R. Morgan (first flight)
Mission Specialist: Richard A. Mastracchio (second flight)
Mission Specialist: Tracy E. Caldwell (first flight)
Payload: ISS Assembly Flight 13A.1; ITS S5, third starboard truss segment; External Stowage Platform 3 (ESP3); SPACEHAB single cargo module
Projected launch date is June 2007, with Endeavour (OV-105) in its 20th flight

The STS-116 Reporter's Space Flight Notepad was produced by Creative Services in Huntington Beach, Calif.

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Boeing in Space

The Boeing human space flight legacy spans more than 45 years, including development of the space shuttle and International Space Station.

Boeing maintains its tradition today by integrating space shuttle systems and payloads and providing orbiter engineering support. Boeing also acts as the lead contractor for the International Space Station—planet Earth's permanent orbital outpost. The ISS is the greatest construction project of humankind, rivaling the pyramids of Egypt, the Suez and Panama canals, or the Great Wall of China.

With an eye on the future, Boeing engineers and scientists are developing technologies to return to the moon and explore Mars someday, while increasing human presence in space.

PUB 3546-U Rev 12-06